DEEP WELLS DRILLED IN IOWA 1928-1932

by

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INTRODUCTION

The general geologic section for Iowa on which the following notes are based is given in tabular form facing page 316. This table is identical with that which appeared in vol. XXXIII, Deep Wells, except for certain recent revisions of the Pleistocene section by G. F. Kay and others, and of the Cambrian section by A. C. Trowbridge and others.

This report sets forth the data of Iowa deep wells that have come to the author's hands since the completion of his report of 1928. The significance of these data is discussed in the notes on the several well sections. The Bellevue well confirms the existence and character of the unnamed formation lying immediately below the Saint Peter sandstone, which was disclosed in the Maquoketa, DeWitt, and Preston wells. The Shellsburg well fixes the position, hitherto in some doubt, of the Independence fossiliferous shales, and it exhibits the Hoing sandstone in some force. The Vinton well adds considerably to the maximum known thickness of the Wapsipinicon Devonian and exhibits a nondolomitic Galena limestone. The New London and Fulton, Illinois, wells penetrate the Cambrian to unusual depths and deserve the attention of all students of its deeper formations. The New Sharon well brings up the problem of the high mineralization of certain waters and that of the origin of solution channels in deep-lying limestone terranes. Wells at Harper and West Point shed additional light on the underground geology of southeastern Iowa, and the well at Sac City shows the changes undergone by the Paleozoic formations in their extension westward across the state. The wells of this report confirm for their localities the substantial accuracy of the author's contour map of the top of the Saint Peter sandstone.[1] Exception must be made of the Sac City well, which moves the contour of 200 feet below sea level from south of the town to the north of it. This contour map, which has formed a part of the author's last three reports on Iowa deep wells, is here omitted. Nor has it been thought necessary to include cross sections, since many of these, illustrating the subsurface geology of almost

1 Deep Wells of Iowa, Iowa Geol. Survey, Vol. XXXIII, Pl. 1.

the entire state, have already been published in the author's papers, and one especially, the Baraboo-Des Moines section, has repeatedly been reprinted by the Survey.[2]

The assistance of well drilling and engineering companies in supplying well logs, cuttings, and various other data is gratefully acknowledged. In the well logs published, the author is responsible for the assignment to geological formations.

Bellevue, Jackson County

In 1930 two deep wells were completed in Bellevue by C. W. Varner of Dubuque. The first, completed in February, was drilled for the United States Bureau of Fisheries. It is located near the bank of Mississippi River about 100 feet south of the small stream (Mill Creek) which enters the river just south of the town. The depth is 1,040 feet; the diameters are 12 inches to 19 feet, 8 inches thence to the bottom. The well is cased to 19 feet. The main supply enters the well below the Jordan sandstone, from 800 feet to the bottom. The static level was not measured. When casing was extended 10 feet above the surface, the well had a natural flow of 300 gallons per minute; when casing was extended 32 feet above the surface, water rose to the top with a flow not measured. The flow has been maintained for more than two years since completion of the well. The elevation of the curb is stated by the driller to be about 30 feet below that of the city well. The second well, completed in June, was drilled for the town of Bellevue. It is 1,186 feet deep, and its diameters are 16 inches to 100 feet, 10 inches to 517 feet, and 8 inches thence to the bottom. The principal supply was found below the Jordan horizon. As in the Fisheries well, the sandstones of the basal formation of the Saint Peter group either were dry or yielded a comparatively small amount. The natural flow was 260 gallons per minute. In the two years since completion the well has "lost flow." The well is cased as follows: 16-inch pipe to 43 feet; 10-inch pipe from surface to 100 feet, the space about it being filled with cement; 8-inch pipe from 474 to 517 feet, to case out caving shale in the basal formation of the Saint Peter group. The well is located on the terrace of Mississippi River with a probable elevation of about 617 feet. A fine set of samples, taken every five feet, was received at this office from Bellevue, but unfortunately it is uncertain to which of the two wells it belongs, or whether both wells may not

2 Artesian Wells of Iowa: Iowa Geol. Survey, Vol. VI, Fig. 35.

General Section of Iowa Strata

Group	System	Series	Formation	Character
CENOZOIC	Quaternary, patches of Tertiary	Pleistocene or Glacial	(Recent)	Soil, geest, alluvium
			Eldoran — Wisconsin	Boulder clay
			Eldoran — Peorian	Loess, forest bed, sand, gravel
			Eldoran — Iowan	Boulder clay
			Centralian — Sangamon	Gumbotil, soils, forest bed, sand, gravel
			Centralian — Illinoian	Boulder clay
			Ottumwan — Yarmouth	Gumbotil, peat, soil, sand, gravel
			Ottumwan — Kansan	Boulder clay, gravel
			Grandian — Aftonian	Gumbotil, peat, soil, gravel
			Grandian — Nebraskan	Boulder clay, gravel
MESOZOIC	Cretaceous	Upper Cretaceous	Colorado	Shale, limestone
			Dakota	Sandstone
PALEOZOIC	Permian	Fort Dodge		Gypsum, shale
	Pennsylvanian	Missouri	Wabaunsee Shawnee Douglas Lansing Kansas City	Limestones, shales, coal
		Des Moines	Pleasanton Henrietta Cherokee	Shales, coals, sandstones, limestones
	Mississippian	Iowa Series — Meramec	Ste. Genevieve (Pella) St. Louis Spergen Warsaw	Limestones, marls, sandstones
		Iowa Series — Osage	Keokuk Burlington	Limestones
		Iowa Series — Kinderhook		Shale, limestones
	Devonian	Upper Devonian	Lime Creek — State Quarry Cedar Valley Wapsipinicon — Davenport Wapsipinicon — Independence Wapsipinicon — Otis	Shale, limestones Limestone, shale Limestone Shale Limestone
	Silurian	Cayugan?	Salina ? nowhere exposed	Limestone, gypsum
		Niagaran	Gower Hopkinton	Dolomites
		Alexandrian	Waucoma	Limestone
	Ordovician	Cincinnatian	Maquoketa	Shale, dolomite
		Mohawkian	Galena Decorah Platteville	Dolomite Shale, limestone Limestone, shale
		Canadian	Glenwood St. Peter Prairie du Chien — Shakopee Prairie du Chien — New Richmond Prairie du Chien — Oneota	Shale Sandstone Dolomite Sandstone Dolomite
PALEOZOIC	Cambrian	Saint Croixan	Trempealeau — Jordan Trempealeau — Lodi Trempealeau — St. Lawrence Franconia Dresbach — Galesville Dresbach — Eau Claire Dresbach — Mt. Simon	Sandstone Siltstone, sandstone, limestone, shale Dolomite Glauconitic sandstone, shale, limestone Sandstone Shale, sandstone Sandstone
	Cambrian (?)	Red Clastic Beds		Sandstone, shale, conglomerate
PROTEROZOIC	Algonkian	Huronian	Sioux	Quartzite
ARCHEOZOIC	Laurentian?		Nowhere exposed	Granite, schist

be represented. The samples below 1,040 feet clearly belong to the city well, and it is the opinion of the contractor that his foremen may have shipped all the samples from this well. The altitudes in the following record of strata are based on the assumption that this was the case.

Record of Strata	Depth in Feet
No Sample	0–5
Ordovician:	
Galena-Platteville (325 feet thick; top 612 feet above sea level) —	
Dolomite, yellow, blue-gray, and brownish, cherty at 130-150, 180-190, and at 210; 26 samples	5–235
Limestone, light gray, rapid effervescence in cold dilute HCl; 3 samples	235–250
Limestone, gray and brownish, some flakes of brown inflammable shale; 2 samples	250–260
Shale, blue and green, calcareous	260–265
Limestone, gray and brownish, rapid effervescence, in sand; 4 samples	265–285
Limestone, brownish, in large chips, highly argillaceous	285–290
Limestone, gray and light gray; 7 samples	290–325
Limestone, brown	325–330
Glenwood (5 feet thick) —	
Shale, blue-green, finely laminated, noncalcareous	330-335
Saint Peter sandstone (60 feet thick; top 282 feet above sea level) —	
Sandstone, white, grains well rounded and frosted, up to 1 mm. in diameter	335-340
Sandstone, white, finer than above; 4 samples	340–365
Sandstone, grains as above, yellow and buff in mass; 6 samples	365–395
Formation unamed (285 feet thick; top 222 feet above sea level) —	
Sandstone, dark red, hard, noncalcareous, grains of clear quartz of Saint Peter facies, interstitial filling red and ochreous, in chips; sandstone, light red and buff, in chips; chert, white; dolomite, light gray; some chips composed of dolomite, chert and quartz sand with chert as matrix; much loose quartz sand up to 2.5 mm. diameter, reddish buff in mass; a chip, dark, siliceous, with bright red band 1 mm. wide; blackish siliceous chips finely quartzose; chips of dark, highly pyritic sandstone	395–400
Sandstone, buff in mass, some grains show bright red stains and ochreous red interstitial cement, fine to medium, larger grains well rounded	400–405
Sandstone, darker buff, as above	405–410
Sandstone, medium dark red, secondary enlargement of grains; some bright yellow shale, noncalcareous, minutely quartzose; a fragment of shale, drab, feebly calcareous, fossiliferous	410–415
Sandstone, reddish buff	415–420
Sandstone, buff, some crystalline enlargements	420–425
Sandstone, light brownish buff; 2 samples	425–435
Sandstone, light chocolate-brown, with considerable argillaceous material	435–440
Sandstone, dark reddish brown, in friable concreted masses owing to argillaceous material; washed grains of clear quartz remain somewhat stained; 6 samples	440-470
Sandstone, brownish buff, secondary enlargements	470–475
Sandstone, brown and reddish brown, somewhat concreted; 6 samples	475–510
Sandstone, light pinkish buff, grains mostly clear and colorless, mass color due to some grains stained ocher yellow and chips with noncalcareous ochreous cement; 4 samples	510–530
Sandstone, reddish brown; 2 samples	530–540
Sandstone, bright ocher yellow, grains of clear quartz stained, color remains after washing and only partly removed by boiling in HCl; secondary enlargements	540–545
Sandstone, dark reddish brown	545–550
Sandstone, terra cotta pink	550–555
Sandstone, reddish brown	555–560

Sandstone, bright ocher yellow, reddish at 575; 3 samples---------- 560–580
Sandstone, ocher yellow, some chips of light gray dolomite up to 0.75 cm.; 2 samples ---------- 580–590
Dolomite in chips as above, some with irregular pitted or vesicular surfaces; shale, dark brown, hard, noncalcareous; shale, red and green interlaminated; much quartz sand; buff in mass---------- 590–595
Dolomite, gray and blue-gray, in large chips; sand reddish buff in masses, a little red and green interlaminated shale in large fragments; 3 samples ---------- 595–610
Chert, white and gray, in chips and irregularly surfaced pebbles, one being 1.2 cm. diameter; chips and slightly rounded pebbles of white sandstone; a little dolomite; much quartz sand; chips of red shale; all concreted by red clay into masses friable with difficulty------- 610–615
Shale, light green, dark blue-green, and red, in chips; sand and clay, brick red; large chips of red and light green-gray sandstone intermingled, red sandstone with matrix of brick red clay; green-gray sandstone of fine irregular grains in argillaceo-siliceous matrix---- 615–620
Shale, red-brown; sandstone fine to medium grains, brightly stained red; some light gray dolomite; some grains of cryptocrystalline silica; some green shale ---------- 620–625
Chert with crystalline silica in irregular masses; dolomite, gray, vesicular, sporadically arenaceous, in large chips; shale, red and green; red sandstone and shale interlaminated; all concreted by red powder of shale into hard masses; 2 samples---------- 625–635
Concreted reddish brown masses of powdered red shale containing sand stained red; gray arenaceous dolomite in large chips; shale in chips 635–640
Concreted dark reddish brown masses of powdered shale, inclosing chips of green shale; red arenaceous shale; chert, pinkish, some arenaceous with fine rounded grains, and red stained sand---------- 640–645
Shale, bright venetian red, in chips and in concreted powder inclosing chips of pink sandstone; and pink chert, with inclosed particles of bright red shale and sporadic grains of quartz sand---------- 645–650
Concreted dark reddish brown masses of powdered red shale inclosing sand; chips of white chert with irregular surfaces stained red; sandstone, whitish, argillaceous matrix; a little gray dolomite; chips of red shale; 2 samples---------- 650–660
Concreted red brown masses of powdered red shale inclosing chips of hard dark red shale; light green shale; quartz sand stained; chips of sandstone, whitish, fine, hard, with considerable cryptocrystalline silica; a large chip of highly arenaceous light green shale with fine to medium rounded grains---------- 660–665
Shale, dark iron red; shale, green; chert, white and gray; stained sand, not so much concreted as above; 3 samples---------- 665–680

Prairie du Chien: Oneota (30 feet thick; top 63 feet below sea level) —
Chert, light yellow-gray, slightly arenaceous, grains minute; some chips of red and green shale from cave---------- 680–685
Chert, as above, stained yellow, some chips sparingly arenaceous with rounded medium-sized grains of sand; some smooth spherical grains of siliceous oölite ---------- 685–690
Sandstone, ocher yellow, rounded grains; much white chert; oölite as above; a fragment of chert with a rough and decayed surface partly covered with drusy pyrite---------- 690–695
Same, less chert ---------- 695–700
Chert, white, in fine chips, some arenaceous; and quartz sand stained ocher-yellow ---------- 700–705
Chert, highly arenaceous, white; sandstone, fine, with cherty matrix; loose grains of ocher-yellow sand---------- 705–710

Cambrian:

Trempealeau: Jordan (?) (35 feet thick; top 93 feet below sea level) —
Sandstone, fine, white, in chips and loose grains stained yellow-------- 710–715
Sandstone, light buff in mass from grains stained ocher-yellow, in loose grains, some concreted masses with whitish argillaceous powder at 725; 3 samples ---------- 715–730

Dolomite, gray, in fine chips, some minutely arenaceous; chips of white noncalcareous sandstone; most of sample loose yellow sand 730–735
Sandstone, very light gray, grains minute, dolomitic cement; a little dolomite; 2 samples 735–745
Trempealeau: Lodi and St. Lawrence (115 feet thick; top 128 feet below sea level) —
Dolomite, gray, sporadically arenaceous; much quartz sand; 5 samples 745–780
Dolomite, as above, buff in mass, sporadically arenaceous 780–785
Dolomite, light gray with quartz sand; 3 samples 785–800
Dolomite, very light gray, finely quartzose, slightly glauconitic; 4 samples 800–820
Dolomite, dark gray and buff, minutely quartzose, glauconitic; 3 samples 820–840
Dolomite, brown, minutely quartzose; rather large amount of glauconite in minute grains in residue 840–845
Dolomite, pink in mass; 2 samples 845–855
Dolomite, gray, glauconitic, minutely quartzose, red brown in mass from powder of red shale; some dark gray dolomitic sandstone highly glauconitic 855–860
Franconia (85 feet thick; top 243 feet below sea level) —
Sandstone, red from argillaceous content, of minute grains; dolomite, gray, glauconitic 860–865
Sandstone, pink, minute grains, dolomitic, glauconitic, argillaceous, in concreted masses friable with difficulty; 2 samples 865–875
Sandstone, light greenish gray, dolomitic, argillaceous, glauconitic, in lumps as above; 2 samples 875–885
Sandstone, grains minute, green-gray, brighter and darker than above from larger amount of glauconite, argillaceous, dolomitic; 11 samples 885-930
Shale, highly siliceous with minute quartzose grains, greenish gray, some translucent cryptocrystalline silica, dolomitic, sparingly glauconitic .. 930–935
Shale, venetian red, in concreted masses, inclosing some flakes of green dolomitic slightly quartzose shale; dolomite, hard, red, argillaceous, cherty, minutely arenaceous; dolomite, gray, minutely arenaceous, glauconitic 935–940
Dolomite, gray, arenaceous with rounded grains, glauconitic 940–945
Dresbach: Galesville (140 feet thick; top 328 feet below sea level) —
Sandstone, light grayish buff in mass, well rounded grains of colorless quartz up to 1 mm. diameter; 21 samples 945–1050
Sandstone, clear quartz sand, finer than above; 7 samples 1050–1085
Dresbach: Eau Claire (penetrated 55 feet; top 468 feet below sea level) —
Sandstone, buff, very fine, glauconitic 1085–1090
Sandstone, as above, fine 1090–1095
Sandstone, fine to medium, grains well rounded, frosted, some stained with ferric oxide, giving light yellow color to mass; glauconitic; 9 samples 1095–1140
Unknown, no samples 1140–1186

Notes. — At Bellevue the high bluffs fronting the Mississippi comprise a bold escarpment of massive Niagaran limestone crowning a long slope, the outcrop of the weak Maquoketa shale. The Galena dolomite outcrops a few feet above water level at points along the river terrace. The well sections, therefore, probably measure the full thickness of the Galena-Platteville at this locality. The upper dolomitized portion is much thicker than the limestones and shales on which it rests, as is the case usually in Jackson and Dubuque Counties, both in outcrops and deep wells.

The Glenwood shale, though unmistakeably present, is thin, a condition common in this area.

The drill at Bellevue disclosed beneath the normal Saint Peter sandstone the same unnamed formation, assigned to the Saint Peter group, which the writer has described from the wells at Holstein, Maquoketa, DeWitt, and Preston. The significance of these deposits has been discussed at length.[3] In brief they mark one of the major unconformities of the geologic history of the Upper Mississippi valley, a long erosion interval after the deposit of the Prairie du Chien dolomites, during which these marine limestones and the beds beneath were uplifted to form land and were deeply weathered to red residual soils. An uplift brought about the deep dissection of this ancient land and the rapid stripping of its soils with their deposition in valleys and basins under conditions which forbade the reduction of their iron content. A later depression brought in the transgressing sea, reworking in part, at least, these ferruginous deposits and later laying down the sands of the Saint Peter as seen in its normal outcrops and deep well sections.

As Trowbridge[4] has pointed out, the outcrops of the Saint Peter in Iowa show valley fills of ferruginous sands, as at Pictured Rocks, McGregor, which include residual cherts at Church, Allamakee County. A well sunk at Pictured Rocks would supply stained sands indistinguishable in their colors from those of the Bellevue well at the same horizon. However, the basal formation of the Saint Peter group as disclosed by deep wells is far thicker than that seen in any natural outcrop. It includes shales, conglomerates, and dolomitic beds, the last mentioned affording a resemblance to the basal beds of the Saint Peter in Missouri that are named the Everton by Dake.

The varicolored sandstone at Bellevue resembling that at Pictured Rocks in its bright colors of buff, ocher-yellow, venetian red, and brown is 85 feet thick. At top, however, this formation shows a bed not recognized at McGregor — a thin layer of debris containing chert, dolomite (probably from pebbles), red banded shale, and reddish buff sand coarser than that below it or above. The color of this varicolored sandstone is due to ferruginous stain coating the grains and in no case is there enough ochreous or argillaceous material in the cuttings to form hard concreted masses. At 580 feet dolomite appears and at 590 feet it gives place to dark brown and green shales. Dolomite recurs at

[3] Norton, W. H., Deep Wells of Iowa: Iowa Geol. Survey, Vol. XXXIII, pp. 37-42.
[4] Trowbridge, Arthur C., Prairie du Chien-St. Peter Unconformity in Iowa: Proc. Iowa Acad. Science, Vol. XXIV, pp. 177-182.

595 feet. Sand is present in these samples in large amount and is as individual in color as is that of the overlying beds. To what extent it is native is not determined. The character of the underlying strata forbids reference of the dolomite to the Prairie du Chien. From 610 to 680 feet the samples comprise red shales, green shales passing into greenish argillaceous sandstones, much chert, interlaminated red sandstone and shale, red sandstone, varicolored red and greenish gray sandstone, and a few chips of sandy dolomite. The chert is in many cases arenaceous, and chips are found inclosing particles of bright red shale. In these samples the cuttings are concreted by dark reddish clay into masses that are friable with difficulty. The entire 70 feet of this bed resembles the cherty conglomerate found at the same horizon at DeWitt. From 680 to 710 feet the samples consist of stained sands with considerable amounts of chert. Siliceous oölite is found as at DeWitt and is characteristic of the Oneota dolomite. The amount of quartz sand, however, the arenaceous character of the chert, and the surfaces of some of the chert fragments raise the question whether these beds do not belong with those immediately above them. At 710 feet the drill entered a white sandstone 35 feet thick, not of normal Jordan facies, which possibly also should be referred to the basal formation of the Saint Peter. The St. Lawrence dolomite clearly was reached at 745 feet. Below 800 feet it is minutely quartzose and more or less glauconitic. The Franconia is entirely typical, and the Galesville is clearly defined, at least in its upper contact. The Galesville is given about the same thickness as at Fulton by assigning the fine glauconitic sandstone at 1,085 feet to the top of the Eau Claire.

It is noteworthy that the wells in eastern Iowa that disclose this basal formation of the Saint Peter group are all located in an elliptical area in Jackson and Clinton Counties whose longer diameter, north and south, is only about 30 miles. A southward extension of this axis strikes the wells at Moline and East Moline, in Illinois, in which the same formation was found.

Dayton, Webster County, City Well of 1931

The first deep well at Dayton was drilled in 1895. The depth is 688 feet. The well foots in the Kinderhook limestone.

The well of 1931, drilled by the Thorpe Bros. Well Co., is 1,240 feet in depth, and its diameters are from 18 to 8 inches. Water was first encountered at 138 feet in glacial sand, the yield being 25 gallons

per minute. Water was found also from 860 to 900 feet and the main supply at 1,235 feet. The yield is 175 gallons per minute under a drawdown of 103 feet. The static level is 62 feet below the surface. The well is cased with 13-inch pipe to 323 feet, with 10-inch pipe from 312 to 505 feet, and with 8-inch pipe from 770 to 966 feet.

Driller's Log	Depth in Feet
Pleistocene and Recent (144 feet thick; top 1089 feet above sea level) —	
Soil	0–5
Clay	5–75
Gravel	75–77
Clay	77–138
Fine sand	138–144
Pennsylvanian, Des Moines series (241 feet thick; top 945 feet above sea level) —	
Dark shale	144–258
Coal	258–260
Shale and thin streaks of rock	260–385
Mississippian, undifferentiated (304 feet thick; top 704 feet above sea level) —	
Rock and shale alternating	385–410
Rock and thin streaks of shale	410–444
Lime rock	444–689
Mississippian, Kinderhook shale (58 feet thick; top 400 feet above sea level) —	
Light green shale, very soft	689–717
Lime rock	717–735
Gray shale	735–747
Devonian and Silurian (penetrated 493 feet; top 342 feet above sea level) —	
Lime rock	747–1240

Notes. — The terrane "shale and streaks of rock" from 260 to 365 feet, is placed with the Des Moines, since the cuttings of the well of 1895 clearly show the shale to be of Coal Measures facies.

In the author's report of 1912 [5] the geologic section of the well of 1895 was drawn with its base (401 feet above sea level) 50 feet above the top of the Devonian, the Kinderhook shale not having been encountered. The allowance thus made for the Kinderhook shale proves sufficient within 8 feet. This shale must lie immediately below the base of the well of 1895. Throughout this area the Kinderhook shale is thin compared with that of its southeastern extension, and it contains more or less intercalated limestones. Its thickness at Dayton, 58 feet, may be compared with that at Gowrie, 50 feet; Fort Dodge (Beaver Products Co. Well No. 3), 50 feet; and Ogden, 80 feet. The drill probably would have struck the Maquoketa shale within a few feet of the bottom of the well.

[5] Iowa Geol. Survey, Vol. XXI, Plate XVI.

Fulton, Illinois, City Well No. 3, 1931

Through the courtesy of Mr. F. T. Thwaites of the Wisconsin Geological Survey we are able to present here the geologic section of this well, the latest drilled in the Clinton-Lyons-Fulton artesian field and the one best sampled. The elevations above sea level are added to Mr. Thwaites' determinations. The static level is 15 feet above the surface, and the natural flow at surface is 200 gallons per minute.

Record of Strata	Depth in Feet
Pleistocene (190 feet thick; top 590 feet above sea level) —	
No samples	0–100
Clay, gray-blue, dolomitic	100–110
Gravel, pebbles chert; sand, coarse, gray, dolomitic; 3 samples	110–130
Sand, coarse, yellowish gray, dolomitic, glacial (?)	130–140
Same as above except finer; 2 samples	140–160
Clay, rusty brown, dolomitic	160–170
Sand, fine, rusty brown, very dolomitic	170–180
Sand, fine, gray, dolomitic, glacial	180–190
Ordovician:	
Maquoketa shale (152 feet thick; top 400 feet above sea level) —	
Dolomite, light bluish gray	190–200
Shale, blue-gray, dolomitic; 9 samples	200–290
Dolomite, dark blue-gray, shaly; 5 samples	290–342
Galena-Black River (348 feet thick; top 248 feet above sea level) —	
Dolomite, light gray, 23 samples	342–570
Dolomite, gray and brown, pyritic	570–580
Dolomite, brownish gray and bluish gray	580–590
Dolomite, gray, blue spots	590–600
Dolomite, light gray	600–610
Same, some blue spots	610–620
Dolomite, gray	620–630
Dolomite, light gray	630–640
Dolomite, gray, blue spots; 2 samples	640–660
Dolomite, light gray, some white, very sandy	660–672
Shale, gray and brown, calcareous	672–682
Sandstone, coarse, gray, pyritic, dolomitic; shale, greenish gray	682–690
Saint Peter (70 feet thick; top 100 feet below sea level) —	
Sandstone, fine to medium, light gray, dolomitic	690–700
Same, lighter color, 2 samples	700–720
Sandstone, medium, white; 2 samples	720–740
Shale, greenish gray; much sand; some soft white chert (?)	740–750
Same, but some white dolomite, very soft; sand not in shale, which is hard and caves	750–760
Prairie du Chien (370 feet thick; top 170 feet below sea level) —	
Dolomite, light gray; chert, white; shale cavings	760–770
Dolomite, light gray; 3 samples	770–800
Sandstone, medium, light gray, very dolomitic	800–810
Dolomite, light gray; 2 samples	810–830
Dolomite, light pink	830–840
Dolomite, light gray; 4 samples	840–880
Dolomite, light gray; chert, white; 2 samples	880–900
Dolomite, light gray; 3 samples	900–930
Dolomite, light gray; chert, white; 2 samples	930–950
Dolomite, light gray; 2 samples	950–970
Dolomite, light gray; chert, white	970–980
Same, mostly chert; 6 samples	980–1040
Same, some yellowish brown chert	1040–1050
Dolomite, light gray	1050–1060

Dolomite, gray; some white chert----1060–1070
Same, more chert, some yellowish brown----1070–1080
Dolomite, gray; some white chert----1080–1090
Dolomite, light gray; 2 samples----1090–1110
Sandstone, fine, light gray, very dolomitic----1110–1120
Dolomite, light gray; chert, white----1120–1130
Cambrian:
Trempealeau: Jordan sandstone (10 feet thick; top 540 feet below sea level) —
Sandstone, medium to coarse, light gray, very dolomitic----1130–1140
Trempealeau: Lodi and St. Lawrence (170 feet thick; top 550 feet below sea level) —
Dolomite, light gray; some sand; 3 samples----1140–1170
Dolomite, light gray and light pink---- 1170–1180
Same, with pyrite, and some dark gray; 2 samples----1180–1200
Dolomite, light gray and light pink, pyritic; 2 samples----1200–1220
Dolomite, light gray and light pink----1220–1230
Same (a few grains of glauconite); 2 samples----1230–1250
Dolomite, pink and gray; some glauconite; 6 samples----1250–1310
Franconia (90 feet thick; top 720 feet below sea level) —
Dolomite, gray and pink, very sandy, very glauconitic; 2 samples----1310–1330
Sandstone, very fine, greenish gray, dolomitic, glauconitic; 3 samples--1330–1360
Sandstone, fine, greenish gray, dolomitic, glauconitic; 1 inch chunk of gray chert in part oölitic----1360–1370
Same; 2 samples ----1370–1390
Sandstone, exceedingly fine, pink and greenish gray, very dolomitic, glauconitic ----1390–1400
Franconia: Ironton (40 feet thick; top 810 feet below sea level) —
Sandstone, fine to medium, light gray, dolomitic, a few glauconite grains; 3 samples ----1400–1430
Sandstone, medium to coarse, light gray, dolomitic----1430–1440
Dresbach: Galesville sand stone (90 feet thick; top 850 feet below sea level) —
Sandstone, medium, white; 2 samples----1440–1460
Same, dolomitic; 2 samples----1460–1480
Sandstone, medium, white; 5 samples----1480–1530
Dresbach: Eau Claire (180 feet thick; top 940 feet below sea level) —
Sandstone, fine, light gray, dolomitic; 2 samples----1530–1550
Same, glauconitic ----1550–1560
Sandstone, fine, pink, glauconitic, slightly dolomitic----1560–1570
Sandstone, medium, light gray, some glauconite, dolomitic; 3 samples--1570–1600
Sandstone, medium, pink, dolomitic----1600–1610
Sandstone, fine to medium, gray, very dolomitic, hard; 2 samples----1610–1630
Sandstone, fine, light pinkish gray, dolomitic, glauconitic; some shale, dark gray ----1630–1640
Same, finer, less shale; 4 samples----1640–1680
Sandstone, fine, red, dolomitic----1680–1690
Sandstone, very fine, gray, dolomitic, glauconitic; 2 samples----1690–1710
Dresbach: Mount Simon (penetrated 233 feet, top 1120 feet below sea level) —
Sandstone, meduim to fine, white, slightly dolomitic; 2 samples----1710–1730
Sandstone, medium to fine, light pink, dolomitic----1730–1740
Sandstone, medium to fine, white, dolomitic; 2 samples----1740–1760
Like above, more dolomitic, hard; 3 samples----1760–1790
Sandstone, medium to fine, white, dolomitic; 2 samples----1790–1810
Sandstone, medium to coarse, white; 14 samples----1810–1943

Harper, Keokuk County

In 1931 the Sewell Well Co. of St. Louis completed a well one mile southwest of Harper for the Continental Construction Co. The depth of the well is 1,530 feet. The diameters, top and bottom, are 20 and

6¼ inches. The elevation of the curb is stated to be approximately that of Harper, 796 feet above sea level. Water was found at the base of the drift at 50 feet; in the Keokuk limestone at 150 feet; in soft dolomitic limestones, probably Silurian, at 730 feet, sulphurous; in Galena-Platteville dolomite at 1,165 feet; in the Saint Peter at 1,303 feet; and in the New Richmond sandstone, the main flow at 1,500 to 1,530 feet.

The head of the Galena-Platteville aquifer was 130 feet below curb. At 1,335 feet, at the bottom of the Saint Peter sandstone, the head had dropped to 182 feet below curb. The head rose to 119 feet below curb on the completion of the well under the pressure of the main flow from the New Richmond.

Casing was placed as follows: 47 feet of 16-inch casing to 47 feet; 153 feet of 12-inch casing to 153 feet; 317 feet of 10-inch casing; 1,002 feet of 8-inch casing. A 6-inch liner from 1,260 to 1,368 feet prevents caving from the Saint Peter sandstone and also prevents lateral escape of water from the New Richmond, whose static head is 63 feet higher than that of water from the Saint Peter.

The well tests 200 gallons per minute.

Record of Strata	Depth in Feet
Pleistocene (55 feet thick; top 796 feet above sea level) —	
Drift	0–55
Pennsylvanian (93 feet thick; top 741 feet above sea level) —	
Shale, mainly blue	55–148
Shale, olive-drab, hard, laminated, in chips and concreted masses, somewhat calcareous	74–100
Mississippian:	
Keokuk (62 feet thick; top 648 feet above sea level) —	
Limestone, very light gray, highly crinoidal, soft, in chips, rapid effervescence in cold dilute HCl; a little chert	148–155
Limestone, whitish and light buff, soft, rapid effervescence; much whitish chert	155–160
Limestone, light yellow-gray, granular, moderately rapid effervescence; much whitish chert; 3 samples	160–180
Limestone, as above; limestone, buff, slow effervescence, siliceous; much chert	180–185
Limestone, light gray, rapid effervescence; much chert	185–190
Limestone, light gray and buff; some chert	190–195
Limestone, as above, very cherty	195–200
Chert, whitish; limestone, yellow, crystalline-granular, moderately rapid effervescence; 2 samples	200–210
Burlington and Kinderhook (100 feet thick; top 586 feet above sea level) —	
Limestone, whitish, soft, in large chips, earthy, highly argillaceous; 3 samples	210–225
Limestone, gray and dark gray, fine-grained, argillaceous, rapid effervescence; 3 samples	225–240
Limestone as above, moderately rapid effervescence; 2 samples	240–250
Limestone, gray, finely crystalline, pyritic; 2 samples	250–260
Limestone, yellow-gray, calcilutite, fossiliferous at 275; rapid effervescence; 5 samples	260–285

Limestone, gray and brownish gray, finely crystalline-granular, in large flakes, rapid effervescence; 2 samples ---- 285–295
Limestone, light yellow-gray, calcilutite; and darker gray, finely granular; rapid effervescence; fossiliferous at 300; 3 samples ---- 295–310
Kinderhook shale (352 feet thick, top 486 feet above sea level) —
Shale, blue, plastic, calcareous; 3 samples ---- 310–370
No samples ---- 370–475
Limestone, gray and blue-gray, argillaceous, earthy, in large flakes, rapid effervescence; 3 samples ---- 475–495
Shale, blue-gray, some olive-drab chips; calcareous, plastic ---- 495–520
Shale, as above ---- 520–540
Shale, as above ---- 540–560
Shale, as above ---- 560–580
(Limestone, light yellow-gray and whitish, rapid effervescence, considerable white chert cuttings, clean of shale. Not listed in log and apparently misplaced, 565-575)
Shale, blue-gray, calcareous, plastic ---- 580–600
Shale as above, with some inclosed chips of drab and olive-drab shale; 3 samples ---- 600–662
Devonian and Silurian (111 feet thick; top 134 feet above sea level) —
Limestone, gray, earthy, argillaceous, in large chips, rapid effervescence; some gray chert; 2 samples ---- 662-675
Limestone, grayish buff, finely-crystalline, rapid effervescence, argillaceous, in rather large chips ---- 675–685
Limestone, medium dark gray, finely crystalline-granular, moderately rapid effervescence; some drusy quartz; white chert; 3 samples ---- 685–715
Limestone, medium dark gray, finely crystalline-granular, moderately rapid effervescence ---- 715–725
Limestone, dolomitic, gray, rather slow effervescence, finely crystalline-granular, casts of fenestella in large chips ---- 730–735
Limestone, dolomitic, brownish drab, rather slow effervescence, cherty, fenestella casts ---- 740–745
Limestone, dolomitic, brown, finely crystalline-granular ---- 745–750
Limestone, dolomitic, gray, some chert ---- 755–765
Dolomite, yellow-gray, cryptocrystalline ---- 765–773
Ordovician:
Maquoketa shale (227 feet thick; top 23 feet above sea level) —
Shale, greenish gray, calcareous, plastic, some hard chips feebly calcareous; 2 samples ---- 773–795
No samples ---- 795–835
Shale, bluish drab, calcareous, plastic ---- 835–875
Shale as above ---- 875–885
No samples ---- 885–938
Dolomite, drab, argillaceous, crystalline-granular; much shale in chips; 2 samples ---- 938–950
Shale, drab, calcareous, plastic, some chips olive-drab ---- 955–975
"Brown shale," no samples ---- 975–1000
Galena-Platteville (285 feet thick, top 204 feet below sea level) —
Dolomite, dark brown; white calcite; a few chips of brown shale, some inflammable; 2 samples ---- 1000–1020
Limestone, gray, earthy, rapid effervescence; a few flakes of brown inflammable shale; 2 samples ---- 1020–1040
Limestone, light yellow-gray, rapid effervescence ---- 1040–1050
No samples ---- 1050–1060
Limestone as at 1,040; 4 samples ---- 1060–1100
Limestone, light buff, moderately rapid effervescence, some light gray, rapid effervescence; chert; 2 samples ---- 1100–1120
Limestone, light buff, crystalline-granular, moderately rapid effervescence, in sand; much white chert; 2 samples ---- 1120–1140
Limestone, light buff and light gray, moderately rapid effervescence; cherty ---- 1140–1150
Limestone, as above, some of rather slow effervescence ---- 1150–1165
Dolomite, light buff and yellow-gray, in crystalline sand; 4 samples ---- 1165–1195

Dolomite as above; limestone light gray; highly cherty; 2 samples....1195–1215
Limestone, gray, rapid effervescence; some chert.....1215–1225
Limestone, light gray, fossiliferous; much brown inflammable shale; 2 samples.....1225–1245
Limestone, light gray, rapid effervescence; 2 samples.....1245–1265
Limestone, medium dark gray, rapid effervescence; 2 samples.....1265–1285
Glenwood formation (18 feet thick, top 489 feet below sea level) —
Sandstone, fine to medium, Saint Peter facies; much brown inflammable shale.....1285–1290
Sandstone, as above, gray in mass.....1290–1300
Sandstone, as above, white, largest grains about 1 mm. diameter, speckled with small splinters of dark greenish shale, feebly calcareous.....1300–1310
"Green shale, cavey".....1300–1303
Saint Peter sandstone (32 feet thick; top 507 feet below sea level) —
Sandstone, etc. as at 1300.....1310–1325
Sandstone, as above; sample largely flakes of dark greenish shale as above; considerable amounts of pyrite.....1320–1330
Sandstone, as above, with much dark greenish shale; chert, white and gray, oölitic.....1330–1335
Prairie du Chien: Shakopee dolomite (145 feet thick; top 539 feet below sea level) —
Dolomite; considerable chert, some oölitic; much shale as above, in large flakes; with some quartz sand as above.....1335–1340
Dolomite, light buff; siliceous oölite.....1340–1350
Dolomite, light buff, cherty.....1350–1360
Dolomite, gray.....1360–1370
Dolomite, light buff, considerable light greenish shale; pyrite; 2 samples.....1370–1390
No sample.....1390–1400
Dolomite, buff, much white chert.....1400–1410
Dolomite, buff, highly arenaceous, imbedded grains; 2 samples.....1410–1430
Dolomite, light brown, cherty.....1430–1440
Dolomite, yellow-gray and buff; 3 samples.....1440–1470
Dolomite, dark brown, cherty.....1470–1480
Prairie du Chien: New Richmond sandstone (penetrated, 50 feet; top 684 feet below sea level) —
Sandstone, dolomitic, light yellow-gray, grains rounded, frosted, up to 1.3 mm. diameter; some chert and siliceous oölite; 3 samples.....1480–1510
Sandstone, light yellow-gray in mass from rust, fine.....1510–1520
Sandstone, as above, but coarser, largest grains 0.5-0.7 mm. diameter..1520–1530

Notes. — The assignment of the beds from 55 to 144 feet is based on the log and its confirmation, so far as it goes, by a single sample. Some corroboration is afforded by the coarse ill-rounded quartz sand found in all cuttings below the shale as far down as 310 feet, where the second casing was bedded. This foreign material would readily be supplied by the basal sand of a Pennsylvanian outlier, even though the seam were too thin to find mention in the log. Such material has been known to find its way down behind a casing. No such thickness of shale occurs at this horizon in the Mississippian, and a Pennsylvanian outlier at Harper has been mapped by Bain in his report on the Geology of Keokuk County.[6]

The cherty limestones, largely magnesian, from 155 to 210 feet are rather clearly the westward extension of the Montrose cherts of the

6 Iowa Geol. Survey, Vol. IV.

Keokuk, and the limestone at 148 feet, although crinoidal, may belong to the same formation. Underlying the Montrose cherts are homogenous limestones, 100 feet thick, which may belong to a single terrane. They show neither the distinctive crinoidal layers expected in the Burlington, nor the intercalated sandstones looked for in the Kinderhook limestones. No Kinderhook oölite was noted. In the absence of fossils the two formations, to one or both of which the beds belong, can not be discriminated.

The Kinderhook shale clearly begins at 310 feet and has a thickness of at least 165 feet, and probably of 352 feet. This maximum is considerably greater than at Morning Sun, Brighton, and New London, where it measures about 280 feet; it is not much in excess of that assigned at Winfield and Donnellson, about 325 feet, and slightly less than at Mount Pleasant, 368 feet. The correlation with the Washington section is close. At Washington the Kinderhook shale has been partly cut away by the erosion of a preglacial channel, but the base of the formation shows a normal dip from Washington to Harper of eight or nine feet to the mile. The correlation with the section at Sigourney, however, is by no means so close. The top of the formation shows a normal dip, but the base is 68 feet higher at Sigourney than at Harper, or if some argillaceous limestones and shales be included with the Kinderhook, it is still 16 feet higher.

The Devonian-Silurian thickness is about the same as at Washington, but much less than at Sigourney, where it measures 317 feet, or with every allowance at least 265 feet. The discrepancy seems due to unconformities: the erosion of the Devonian at Harper, or of the Maquoketa at Sigourney, or both.

The Maquoketa maintains its normal thickness, but thins abruptly southward. The inflammable brown shale found in several well sections near its base probably lies within the "Brown shale" of the log, from 975 to 1,000 feet, and caving supplies the inflammable shale found in cuttings of the upper beds of the Galena.

The Galena-Platteville maintains its usual thickness, exhibiting the not uncommon alternation of limestones, magnesian limestones, and dolomites, with considerable chert. The brown inflammable shale found in the first cuttings of the Saint Peter sandstone is interpreted as cave from the base of the Platteville. The Glenwood and the Saint Peter have the same general relations as at New London (page 332).

The chert of the first cuttings in the Prairie du Chien may come

from residual materials and thus represent an unconformity. The beds assigned to the New Richmond show nothing lithologically distinctive, but their position, only 145 feet below the Saint Peter, forbids their assignment to the Jordan, which lies much deeper in this area.

Driller's log, by George L. Smith	Depth in Feet
Drift	0–55
Blue shale	55–148
Shelly lime	148–152
Gray lime, white flint	152–265
Blue shale	265–277
Gray lime	277–284
Gray shale	284–291
Gray lime	291–302
Blue shale	302–370
Brown shale	370–473
Gray lime	473–494
Brown shale	494–662
Brown lime	662–725
Gray and brown lime, soft	725–737
Brown lime, hard	737–755
Gray lime	755–773
Green shale, cavy	773–810
Blue shale	810–938
Gray lime	938–955
Gray shale	955–965
Brown shale	965–1002
Brown lime	1002–1018
Gray and brown lime	1018–1080
Brown lime	1080–1160
Brown lime, few white specks from top	1160–1170
White sand	1170–1185
Brown lime	1185–1285
Brown lime and white sand	1285–1290
White sand	1290–1300
Green shale, cavy	1300–1303
White sand	1303–1324
Broken sand and shale	1324–1335
Shale and broken lime	1335–1339
Brown lime	1339–1376
Gray lime	1376–1410
Brown sandy lime	1410–1480
Gray lime	1480–1495
Brown lime and white sand	1495–1500
White sand	1500–1530

Keosauqua, Van Buren County

In 1932 a well was drilled for the water supply of Keosauqua by C. W. Varner of Dubuque. The depth is 335 feet. Casing was set as follows: 10-inch to 22 feet, 8-inch from surface to 105 feet, perforated between 25 and 45 feet. A 72-hours' test showed a yield of 116 gallons per minute, the full capacity of the pump, with a draw-down of 24 feet. The static level is 6 feet below the surface. For the above data and for the following log the Survey is indebted to Mr. W. G. Os-

born of Keosauqua, who is also responsible for the assignments to Mississippian formations.

Log of City Well No. 1, Keosauqua	Depth in Feet
Pleistocene (20 feet thick, top 579 feet above sea level):	
Clay, yellow	0–17
Sand and gravel; water	17–20
Mississippian (penetrated 315 feet):	
Limestone, gray above, buff, magnesian below; water. St. Louis	20–50
Limestone and shale, interbedded, gray. Warsaw	50–101
Limestone, buff; water. Keokuk	101–110
Limestone, light gray. Keokuk	110–175
Limestone, buff, magnesian, water. Keokuk	175–185
Limestone, light gray and gray, with chert. Keokuk	185–198
Limestone, white; some water between 240 and 250 feet. Burlington	198–288
Limestone, gray and brown; water at top at contact. Kinderhook	288–292
Limestone, gray, and sandstone, with siliceous inclusions. Kinderhook	292–325
Limestone, as above, with gray shale; water. Kinderhook	325–335

New London, City Well No. 2, 1930

New London's city well No. 1, which is 1,450 feet deep, was drilled in 1916, and is described in volume XXXIII of the Iowa Geological Survey. A second well was drilled in 1930 by Thorpe Bros. Well Co. of Des Moines. The depth is 2,785 feet. On completion the well tested 250-300 gallons per minute on a 48-hour run with a draw-down of but 6 feet. The static level is 185 feet below the curb, 45 feet below the original static level of well No. 1, which tapped the Prairie du Chien aquifers.

"While the water is quite hard, it is not nearly as bad as that of our old well," writes Mr. J. O. Bell, manager of the City Water and Light Department. The water of well No. 1 showed a total hardness of 1,189 parts per million. In this area, then, drilling can continue for 1,000 feet in the Cambrian without striking brine pools and with the prospect of finding better water than that of the Ordovician aquifers.

The well is cased with 252 feet of 10-inch casing, and 1,450 feet of 8-inch casing, making the well impervious to a depth of 1,700 feet. A 6-inch casing was also inserted from 2,300 to 2,500 feet to prevent the caving of certain beds of the Galesville and Eau Claire.

Record of Strata

Gaps in this record are filled when possible from the record of City Well No. 1. Norton, W. H., Deep Wells of Iowa: Iowa Geol. Survey, Vol. XXXIII, pp. 281-283.

	Depth in Feet
No samples or record	0–157
Mississippian:	
Limestone, cream-colored, rapid effervescence in cold dilute HCl; chert, white	157

Sandstone, buff, clayey, somewhat calcareous, sand grains irregular	172
Limestone, as at 157	182
Chert, white; cream-colored limestone	220
Chert, white; some limestone, light buff	230
Limestone, light gray in mass	235
Chert, white; limestone, buff, highly siliceous	248
Limestone, cream-colored, cherty	260
Sandstone, blue-gray, grains minute, angular, calciferous, argillaceous	275
Sandstone, as above	285
Limestone, dark gray, siliceous, argillaceous, residue of minute quartz grains, slow effervescence; limestone, whitish, rapid effervescence	295
Sandstone, blue-gray, grains minute, irregular, calciferous, argillaceous	305
Kinderhook shale (280 feet thick, top 440 feet above sea level) —	
Shale, blue, calcareous; samples at 315, 325, 465, and	470
Devonian (135 feet thick; top 160 feet above sea level) —	
Limestone, blue-gray, highly argillaceous, fine siliceous residue	605
Limestone, brownish buff, rapid effervescence, finely saccharoidal	625
Limestone, brownish buff and gray, rapid effervescence, fossiliferous with fragments of brachiopod shells	640
"Limestone, blue-gray, earthy, fossiliferous, soft; some large chips"	646–651
"Limestone, yellow-gray, effervescence rapid, in fine chips"	651–663
"Limestone, brown, effervescence rapid, earthy, in chips"	663–667
"Limestone, blue-gray, effervescence rapid; pyrite; a little chert"	667-670
Limestone, blue-gray, rapid effervescence	670
Limestone, as above, fossiliferous with fragments of brachiopods	685
Limestone, yellow-gray, rapid effervescence, earthy, fossiliferous with brachiopod fragments	705
Silurian (78 feet thick; top 25 feet above sea level) —	
Limestone, gray, rapid effervescence, in sand, considerable quantity of gypsum and crystals of selenite	740
"Limestone, yellow-gray, effervescence rapid, fossiliferous, in fine chips"	720-730
"Limestone, whitish, rapid effervescence, in flaky chips"	730–740
Gypsum, cream-colored in mass, some limestone of rapid effervescence, all in fine sand	750
Limestone, dark gray, rapid effervescence, much gypsum, in chips and sand	760
Gypsum, gray and white, some limestone	770
Limestone, brown, rapid effervescence; much gypsum in white chips, some slate-colored and blue shale	775
"Limestone, brown and buff, effervescence rapid, in sand; gypsum in white soft masses and chips; 3 samples"	760-796
"Limestone, brown, effervescence rapid, some slow; white chips of crystalline quartz, nongranular, a few cleavage faces noted (altered from anhydrite?)"	796–806
"Limestone, blue-gray, effervescence rapid, some quartz; shale in powder"	806–818
Ordovician:	
Maquoketa shale; Hoing? (34 feet thick; top 53 feet below sea level) —	
"Shale, blue, plastic, calcareous"	818–830
"Shale, blue, in chips; limestone, rapid effervescence; some fine quartz sand in well-rounded grains"	820
Dolomite, gray, rather slow effervescence, arenaceous, grains fine; sandstone, fine, larger grains well-rounded, dolomitic cement; some shale	835
Dolomite, etc. as above	845
"Limestone, blue-gray, highly arenaceous, or sandstone, calciferous"	843–850
"Sandstone, gray, calciferous, larger grains well-rounded, up to 0.6 mm. diameter, in chips and sand"	850–852
Galena-Platteville (282 feet thick; top 87 feet below sea level) —	
"No samples"	852–860
"Dolomite, blue-gray and light buff, cryptocrystalline, in sand"	860–870
Dolomite, buff in mass	875
Dolomite, buff and yellow-gray; 13 samples	915–1090
Limestone, gray, rapid effervescence	1100

Limestone, as above; a little brown shale, inflammable, in small chips-- 1110
Limestone, light buff, moderately rapid effervescence; limestone, gray, rapid effervescence ---------- 1130
"Limestone, light buff, in fine sand, effervescence rather rapid; two samples" ----------1113–1134
Glenwood formation (46 feet thick; top 369 feet below sea level) —
"Sandstone, white, grains well-rounded, some secondary enlargements, larger grains 0.5 mm. diameter"----------1134–1170
Sandstone, as above----------1140–1150
Sandstone, light yellow, very fine, dolomitic---------- 1160
"Shale, green, unctuous, noncalcareous, pyritic"----------1170–1180
Shale, as above---------- 1170
Saint Peter sandstone (40 feet thick; top 415 feet below sea level) —
Sandstone, fine ---------- 1185
No samples ----------1185–1220
Prairie du Chien (562 feet thick; top 455 feet below sea level) —
Dolomite, gray, light gray and light buff, considerable amount of cave shale and some sand, cherty in places; 19 samples----------1220–1470
"Sandstone, clean, white, grains well-rounded and frosted, many larger grains of 1 mm. diameter, some secondary enlargements"--------- 1485
No samples ----------1470–1515
Dolomite, gray, considerable white chert---------- 1515
Dolomite, yellow-gray, arenaceous, grains fine, rounded, some with secondary enlargements; some warped plates very thin (about 1 mm. thickness) of fine shaly material, brown, highly inflammable, but no chips of brown shale---------- 1520
Dolomite, gray, cherty, much drab cave shale, one fragment, 11 mm. diameter, 5 mm. thick, brown, nonlaminated, inflammable shale; a very few small chips of same---------- 1545
Dolomite, gray, cherty---------- 1560
Dolomite, very light gray, macrocrystalline; some cave shale, including a few chips of brown inflammable shale as above; 4 samples-------1590–1615
Dolomite, as above, cherty; some chips of brown inflammable shale at 1,665 and 1,680; dark cave shale in all samples; 7 samples--------1630–1695
Dolomite, dark gray in mass, cherty---------- 710
Dolomite, buff-gray in mass, cherty---------- 1726
Dolomite, light yellow-gray in mass, cherty; 3 samples----------1745–1760
Dolomite, gray, cherty----------1770–1780
Cambrian:
Trempealeau: Jordan sandstone (128 feet thick; top 1,017 feet below sea level) —
Sandstone, fine, white, many secondary enlargements, dolomitic cement or matrix ---------- 1782
Sandstone, as above, grains up to 0.7 mm. diameter, larger grains smooth and frosted, some grains imbedded in cryptocrystalline siliceous matrix ---------- 1800
Dolomite, gray in mass, highly arenaceous, grains fine---------- 1805
Sandstone, dolomitic, fine---------- 1825
Sandstone, buff in mass, grains fine, larger grains well-rounded and frosted, dolomitic ---------- 1835
Sandstone, very fine, dolomitic, imbedded grains, some secondary enlargements ---------- 1840
Sandstone, gray-buff in mass, fine, grains largely broken, larger grains well-rounded and frosted, dolomitic cement; 3 samples----------1860–1890
Trempealeau: Lodi and St. Lawrence (180 feet thick; top 1,145 feet below sea level) —
Dolomite, gray-buff in mass, highly arenaceous, grains as above------ 1910
Dolomite, gray, in large chips---------- 1935
Dolomite, gray, vesicular, cavities lined with dolomite crystals, nests of iridescent pyrite ---------- 1940
Dolomite, gray; 4 samples----------1950–1975
Dolomite, gray, vesicular, cavities lined with crystals of dolomite------ 1985
Dolomite, gray ---------- 1990
Dolomite, light buff in mass----------2000–2015

Dolomite, gray, slightly arenaceous ---------- 2035
Dolomite, light yellow-gray and light buff in mass; 6 samples ---------- 2045–2080
Franconia (260 feet thick; top 1,325 feet below sea level) —
Dolomite, blue-gray, highly arenaceous with minute or microscopic angular grains of quartz, chips speckled with glauconite ---------- 2090
Dolomite, medium dark gray, arenaceous and glauconitic as above ---------- 2100
Dolomite, medium dark gray, highly arenaceous with minute grains; concreted mass of light blue-green shale, highly dolomitic and minutely arenaceous ---------- 2110–2115
Dolomite, highly arenaceous, as above, glauconitic, argillaceous; 5 samples ---------- 2125–2175
Shale, light blue-green, minutely arenaceous, glauconitic, dolomitic, in concreted masses ---------- 2180
Dolomite, dark gray, minutely arenaceous, glauconitic; 3 samples ---------- 2195–2210
Shale as at 2180
Dolomite, buff, vesicular with cavities lined with dolomite crystals; sample misplaced (?) labelled ---------- 2225
Shale, green, minutely arenaceous, dolomitic, glauconitic ---------- 2235
Dolomite, gray, highly arenaceous with minute grains, glauconitic ---------- 2245
Shale, blue-gray, minutely arenaceous, glauconitic, somewhat dolomitic in concreted masses; some flakes of hard, olive-green shale ---------- 2255
Shale, in dark drab chips, noncalcareous, in blue-gray concreted masses; sandstone, buff and light gray, of minute angular particles, sparingly glauconitic, feebly dolomitic, in chips ---------- 2265
Sandstone and shale as at 2265 ---------- 2270
Sandstone, of minute particles, glauconitic, dolomitic; shale, dark olive-green, noncalcareous, in splintery chips ---------- 2280
Dolomite, gray, highly arenaceous as above, glauconitic, in chips; much shale, dark blue-green, noncalcareous, in hard chips ---------- 2285
Sandstone, gray and pinkish, grains minute, angular, speckled with grains of glauconite, dolomitic ----------
Sandstone, grains as above, highly glauconitic, dolomitic cement ---------- 2300
Sandstone, gray and pinkish, grains as above speckled with glauconite ---------- 2310
Shale, drab, in concreted masses ---------- 2315
Second sample, as at 2310 ---------- 2315
Sandstone, as at 2310. From 2265 all the above samples are blue-greenish, drab in mass from shale in powder and chips, and the sandstone is in small chips ---------- 2320
Sandstone, pink, buff and gray, color in mass buff, grains minute, of clear quartz, angular or subangular, an occasional fine grain rounded 2325
Sandstone as above, but green-gray with powder and chips of shale, glauconitic, dolomitic cement ---------- 2340
Dresbach: Galesville sandstone (70 feet thick; top 1,585 feet below sea level) —
Sandstone, in sand and chips, cuttings buff from rust, grains fine to 1.0 mm. diameter, for the most part poorly rounded, pinkish grains not uncommon, dolomitic cement, glauconitic; shale nearly absent ---------- 2350
Sandstone, in sand, buff in mass, fine and up to 1.5 mm. diameter, grains rough surfaced, some pinkish; glauconitic ---------- 2360
Sandstone, brown-gray, grains as above; lumps of bright green glauconitic sandy clay ---------- 2365
Sandstone, 2d sample, iron red, with red clay, grains up to 1.4 mm. diameter, in sand, glauconitic; some chips of fine glauconitic sandstone ---------- 2365
Sandstone, light brownish gray, fine, with some larger grains 1 mm. diameter, many pinkish, in sand, glauconitic ---------- 2370
Sandstone, gray, fine to medium, grains as above, glauconitic; 3 samples ---------- 2380–2395
Sandstone, green-gray in mass, fine to medium, some of the larger grains well-rounded, grains commonly colorless, glauconitic ---------- 2400
Dresbach: Eau Claire (235 feet thick; top 1,655 feet below sea level) —
Sandstone, pink, in chips, cuttings red-brown from red shale and splinters of green shale coated red, grains minute, uncolored, noncalcareous, glauconitic ---------- 2420
Sandstone, as above, but without red shale, in chips; one fragment of

white dolomite mottled with glauconite and arenaceous with minute grains of clear quartz ---------- 2425
Sandstone, as above, noncalcareous, light buff, glauconitic; much slate-colored hard shale; 3 samples ----------2430, 2435, 2460
Sandstone, gray, dolomitic, glauconitic; with much shale as above---- 2470
Sandstone, gray, dolomitic; dolomite highly arenaceous; both glauconitic and both in grains of quartz sand minute; much red-brown and drab shale in large flakes, finely laminated---------- 2500
Shale, greenish drab, noncalcareous, hard, splintery, finely laminated; some red-brown shale ---------- 2515
Sandstone, gray and pinkish, grains minute, dolomitic, highly glauconitic, all cuttings coated with red clay; red and drab shale; two fragments of dark gray dolomite, one 2 cm. thick between bedding planes; highly arenaceous with minute angular grains and highly glauconitic ---------- 2550
Sandstone, pinkish in sand, buff in mass, grains very fine, poorly rounded, glauconitic; on boiling in HCl, color removed from grains 2555
Sandstone, light buff, in chips and sand, noncalcareous, grains very fine, slightly glauconitic; 5 samples----------2575–2610
Sandstone, buff, dolomitic, glauconitic, grains minute; 2 samples------2637–2645
Sandstone, native color light gray, grains very fine, ill-rounded, in chips and sand ---------- 2652
Dresbach: Mount Simon (penetrated 30 feet; top 1,890 feet below sea level) —
Sandstone, light buff in mass, fine with some grains reaching 1.6 mm. diameter; many chips of sandstone as at 2652; very little shale---- 2655
Sandstone, gray in mass, many grains from 1 to 2 mm. diameter, larger grains well-rounded and frosted, in sand; chips of pink nondolomitic sandstone of very fine grain; chips of dark drab sandstone, fine- to medium-grained, slightly dolomitic ---------- 2660
Sandstone, light gray in mass, clean, fine to medium, with some rounded grains of 1 mm. diameter---------- 2675
Sandstone, red and pink, fine- to medium-grained, grains of colorless quartz, but many rusted, only larger grains well-rounded---------- 2680
Sandstone, reddish brown, clean, coarser than above, larger grains 1 mm. diameter; color removable on boiling in HCl; chips of sandstone of minute grains and some dolomite---------- 2685
Sandstone, reddish brown in mass, grains as at----------2685, 2690–2695
Sandstone, light buff in mass, fine grains poorly rounded---------- 2730
Sandstone, reddish brown in mass, larger grains rounded 1.0 and 1.5 mm. diameter ---------- 2735
No sample "practically same as last sample only got much whiter, finer and soft" ----------2735–2785

Notes. — There is some difficulty in correlating the beds above the Kinderhook shale with those of natural sections of this area. The sandstone overlying the Kinderhook shale is evidently identical with that occupying the same stratigraphic place in the Prospect Hill section at Burlington[7] although the latter measures 22½ feet thick, while the samples at New London appear to represent a bed 40 feet in thickness. At Mount Pleasant this sandstone has a thickness of 52 feet, but is argillaceous at top and includes some shale.

The Kinderhook shale should possibly include the argillaceous limestone here placed as the upper beds of the Devonian, which would give it a thickness of 310 feet. This measure is exceeded at Mount Pleasant

7 Van Tuyl, F. M., Iowa Geol. Survey, Vol. XXX, p. 54.

and Donnellson. The brown inflammable shale found in this formation at Keokuk, Mount Pleasant, and Brighton is not represented in the few samples of the shale at New London.

Considering the notable deposits of gypsum in the Silurian of Mount Pleasant and its occurrence at the same horizon at Fairfield, Brighton, Pella, and Des Moines, the gypsum in the cuttings at New London from 750 to 796 feet was to be expected. The absence of evidence of gypsum at Burlington may well be due to lack of data. At Harper the Silurian can not be discriminated, and to the south, at Donnellson and Keokuk, the Silurian apparently has feathered out.

The beds from 818 to 852 feet are referable either to the Maquoketa shale of the Ordovician or to the Hoing sandstone commonly assigned to the Silurian. In their arenaceous content the beds in question are quite like those referred to the base of the Silurian at Washington, Sigourney, Des Moines, Stuart, Centerville, Shellsburg, and Greenfield. At Ogden, 70 feet of chert, with quartz sand and a very little dolomite, overlies the shale assigned to the Maquoketa. The Hoing formation in its type localities in western Illinois is described as spotty and discontinuous in distributon and lenticular in its deposits, with a thickness ranging from 5 to more than 30 feet. It is supposed to lie unconformably on the Maquoketa, occupying hollows in the erosion surface developed on the shale during the erosion interval preceding the deposition of the Niagaran limestone. The Hoing is thus supposed to consist of land deposits reworked by the transgressing Niagaran sea. There are instances, however, among the deep well sections of Iowa where similar arenaceous deposits occur more intimately related to Maquoketa shales. At Mount Pleasant fine quartz sandstone appears 22 feet below the top and 15 feet above the bottom of the shale. At Iowa City cuttings of arenaceous shale, dolomite, and lumps of decayed chert mark a bed 12 feet thick, which lies 63 feet above the base and 118 feet below the top of the Maquoketa. At Charles City, where the Maquoketa is 90 feet thick, the basal stratum of the formation is a fine sandstone associated in the cuttings with an argillaceous dolomite, and the summit beds also are sandy. At Fort Dodge, city well No. 8, the base of the Maquoketa includes chert and sandy beds.

The Glenwood and the Saint Peter, as at Harper, are more intimately connected than is common in deep well sections in Iowa. Taken in connection with examples where the Glenwood consists of shale only, where the shale is sandy, and where it is entirely wanting, we

have several variations on a single theme. The Glenwood is a transitional formation between the Saint Peter and the Galena-Platteville; the three formations belong to a continuous cycle of sedimentation unbroken by emergence and erosion. Close as are the normal relations of the Glenwood shale with the Platteville limestone and the Decorah shale, they may be even closer with the Saint Peter sandstone, as at New London and Harper.

The epoch during which the sands of the Saint Peter were laid down closed under conditions of rapid change, which often permitted the calcareous silts of the Platteville to be laid directly on the Saint Peter sandstone. In certain areas under a slower subsidence, however, or other differing conditions, the coarser clastics of the Saint Peter were succeeded by the fine sea muds now known as the Glenwood shale. Continuously deepening waters and retreating shores gave rise to the limy silts of the Platteville, while a little later a slight oscillation produced the shales of the Decorah. Not infrequently, however, after the deposition of the shales of the Glenwood, an oscillation led to the recurrence of the conditions favorable for the deposition of sandstone, still of Saint Peter facies. Again, as shown in several well sections of north-central and western Iowa, conditions long favored the deposition of a heavy shale which may include the Glenwood, Platteville, and Decorah formations, so far as our data show.

On such varying natural sequences it is difficult to impose any cast-iron classification. It seems fairly clear, however, that, apart from the evidence of fossils, and with only such proofs as deep wells supply, the Saint Peter is linked closely through the Glenwood with the Middle Ordovician Galena-Platteville. On the other hand, it is in many places separated from the Lower Ordovician Prairie du Chien by residual deposits of the same significance as the unconformities observed in the Wisconsin outcrops.

The Prairie du Chien, here given a thickness of 562 feet, shows an evident thickening southward from its measures of 380 feet at Washington, 460 feet at Grinnell, and 440 feet at Bettendorf. About the same thickness, 565 feet, is seen at Burlington, and at Mount Pleasant, where it is 527 feet; and it is out of the question to suppose that at New London the Trempealeau dolomite is included mistakenly with the Prairie du Chien. Continuing its thickening toward the south, the formation has a thickness of 760 feet at Keokuk. The New Richmond sandstone is not in evidence. The brown inflammable shale found in

samples from 1,545 to 1,680 feet is interpreted as cave material from the usual horizon near the base of the Platteville. It is not represented in Prairie du Chien cuttings from well No. 1.

The Jordan sandstone reaches an exceptional thickness of 128 feet and is dolomitic throughout. Both the St. Lawrence and the Franconia (Saint Lawrence dolomite and shales of earlier reports) run true to form and need no comment. The Galesville is far from typical and is distinguished with some uncertainty from the sandstones of microscopic grain and the shales of the formations between which it lies. The distinction is based chiefly on the presence of decidedly coarser sand and the fact that shale is practically absent. Like them, however, it is here glauconitic. The transition to the Eau Claire is marked by hard, usually noncalcareous, sandstones of microscopic grain and hard splintery shales. The Mount Simon is rather sharply set off by softer nonglauconitic sandstones of coarser grain and by the general absence of shale.

The New London section, well attested with authentic sample cuttings, penetrates the Cambrian to the very unusual depth of 1,003 feet, 203 feet deeper than that of the Crapo Park well at Burlington. It thus becomes of exceptional value in the interpretation of the Cambrian of Iowa.

New Sharon, Mahaska County

In 1930 a deep well was completed for the town of New Sharon by the Thorpe Bros. Well Co. of Des Moines. The well is 2,139 feet deep, footing in the St. Lawrence dolomite. Special interest attaches to this well on account of the prolonged efforts to obtain a potable water in an area where the mineralization of the waters of the higher strata is excessive.

The first test of the well was made on reaching the Shakopee dolomite. The well had been now cased to the top of the Saint Peter sandstone and the static level stood at 108 feet below the curb. The well yielded 90 gallons per minute with a draw-down of 25 feet, and 150 gallons per minute with a draw-down of 40 feet. Analysis (No. 2, table p. 340) shows the quality of the water. The similarity of the water to that of Mississippian well waters of the region suggested the possibility that the upper waters had not been cased out successfully.

Drilling was resumed and the well carried to its full depth. The Saint Peter was cased out, leaving only the large flows entering the well

from the Prairie du Chien and the Jordan sandstone. The head was now found to be at 149 feet below the curb. Pumping 200 gallons per minute showed a draw-down of but a foot and pumping 300 gallons per minute a draw-down of but 6 feet. The water, however, continued to be highly mineralized (analysis No. 3).

To test the quantity and quality of the water from the Jordan sandstone a 4-inch pipe was now set, joining the bottom of the pipe which cased out the Saint Peter and extending to the bottom of the well. This pipe was perforated for 40 feet from the bottom to let in the water of the Jordan aquifer, and a rubber packer was placed at the top of that formation. The static level now rose to 112 feet, about its level at the first test. The yield at this level was evidently insufficient. It was suspected that the leakage of upper waters was responsible both for the head and for the high mineralization which still remained.

A 6-inch pipe was now placed, reaching from the curb to the top of the 6-inch pipe already in the well in order to effectively exclude all but the water of the Jordan. The head now fell to 149 feet within the pipe, while it remained at 114 feet outside it. There was a heavy draw-down when pumping 159 gallons per minute. The lowered head seemed to imply that the influx of upper waters had been greatly lessened, if not entirely prevented. An analysis (No. 4) showed a marked improvement but by no means the good quality to be expected. As the yield of the Jordan sandstone was relatively small, and as there was no reason to suppose that the quality of the Prairie du Chien waters was inferior, the 4-inch casing shutting these waters out was now pulled. The head then stood at 155 feet. A pumping test of 66 hours showed a capacity of 280 gallons per minute with a draw-down of but 5 feet. The analysis of the water (No. 5) showed a marked reduction in total solids and in each deleterious ingredient, but the water remained one of the most heavily sulphated of Iowa deep wells and more highly mineralized than any in use as a town supply. The table includes some of the most highly mineralized deep well waters for comparison.

Evidently either the quality of the Cambro-Ordovician waters was truly represented in the last analysis, or the utmost efforts of experienced and skilled drillers had not been able to prevent entirely the influx of upper waters. In either case it remained only for the town to decide whether the water could be safely used. It was pointed out that, though the water was very bad as a boiler water, this fact might be disregarded in a nonindustrial town. Hendrixson has said, in summing up

the effects of such waters on health: "Apparently waters containing more than 2,000 parts of mineral matter are unpalatable, and this amount may be taken as the maximum amount allowable in a water supply for city use and particularly for drinking. An organically pure water with 2,200 parts may be considered usable if no better can be obtained." This limit is set by Hendrixson largely because of unpalatability; for he also states regarding water containing only this maximum amount of 2,000 parts per million: "So far as is known no serious effects on the health of the people can be traced to the use of such waters." [8]

More specifically it was pointed out that any possible injury to the health of the users of this water would lie in the large amounts of the sulphate, sodium, and magnesium ions. In Maffitt's hypothetical combinations these totaled to the gallon 105 grains of sodium sulphate (Epsom salt) and magnesium sulphate (Glauber's salt). Thus one drinking six glasses (a quart and a half) of the water a day would take in 39 grains daily of these laxatives. A usual dose of either of these salts for gentle laxative effects is from 15 to 30 grains after each meal, or from 45 to 90 grains a day. The continuous use of about 39 grains per day could hardly be considered healthful. The effects, no doubt, would depend on the habit of the user. Those habitually constipated might be temporarily benefited. The first pronounced effects might be expected gradually to wear off. The general effects would be that of the continued use of the Mississippian waters of Colfax Springs, not the public supply but that of the Old M. C. Spring, containing 113 grains per gallon, and the M. R. S. Spring, containing 88 grains per gallon of the same laxatives. It was further pointed out that, if the drift wells of New Sharon's city supply were still used in part, the dilution of the water of the deep well would lessen its deleterious effects.

The following opinion was obtained from Dr. Edward Bartow of the State University of Iowa: "A water with 3,512 parts per million of residue should not be used for a water supply if it is possible to obtain anything else, or if it is possible to improve it.

"With regard to treating the water, that seems impossible. Treating with lime would remove some of the calcium and magnesium, but a considerable part of the sodium sulphate would still remain. People can become accustomed to water of this type, but strangers coming into

8 Hendrixson, W. S., Iowa Geol. Survey, Vol. XXI, pp. 233-234.

town would probably be quite upset by the water until they got accustomed to it.

"From the information at hand, it would seem to me that the water should not be used for municipal supply if it is possible to get another in any way, or by further casing out of the highly mineralized water to improve this one."

Because of the high mineralization of the water the deep well was finally abandoned, and in October, 1931, the Thorpe Bros. Well Co. put down a Thorpe patent gravel-treated well, 130 feet deep, 12 inches in diameter, with three 6-inch side holes drilled to feed the gravel about the strainer. Water was found at 70 feet and the well is cased to that depth. The yield is 120 gallons per minute.

A letter from New Sharon of date of April 25, 1932, states: "The water tastes the same as the water we had from our old wells and is a little softer. This well solves the water problem here very satisfactorily, and I think we are fortunate in being able to get a well like it after having so much trouble. The deep well is still cased, and we have considered putting a hand pump in it so that those who care to do so can get water there for drinking purposes. The water seems to produce a mild laxative effect and some of our citizens have expressed a desire to use it for that purpose."

TABLE

Analyses of New Sharon and Other Deep Well Waters in Parts Per Million

Ions	New Sharon					North English	Belle Plaine	New London, No. 1	Rippey
	1[a]	2[b]	3[c]	4[d]	5[e]				
Calcium	82.9	1596.0	1205	314.	298.	269	346	86	153
Magnesium	25.1	98.5	83	77.	75.	107	135	35	71
Sodium and Potassium	4.6	48.2	114	G23	549.	62	83	272	214
Sulphate	8.6	3831.6	2606	2256	1951.	1463	1247	492	729
Chloride	7.1	74.4	178	168	136.	64	9	149	110
Bicarbonate	369.5	501.0	788	234	317.	(103 CO_3)	268	261	317
Silica iron and H.	3.2	72.0	15	42	31.				
Total Solids	501.0	6221.7	4540	4134	3512	2079	1980	1189	1463

a Water of old city wells in drift, Dr. Nicholas Knight, Cornell College, Feb. 22, 1931.
b-c Waters of deep well, Dr. Nicholas Knight, Cornell College, Oct. 29, 1929, Apr. 10, 1930.
d Water of deep well, H. G. Day, Cornell College, July 22, 1930.
e Water of deep well, Howard Maffitt, Des Moines, Aug. 28, 1930.

Driller's log and record of strata. New Sharon deep well, 1930.

	Depth in Feet
Pleistocene and Recent (135 feet thick; top 870 feet above sea level) —	
"Black soil"	0–3
"Yellow clay"	3–15
"Yellow sandy mud"	15–27

"Yellow clay" ---------- 27–41
"Yellow sandy mud" ---------- 41–104
"Coarse gravel" ---------- 104–112
"Sandy clay" ---------- 112–135

Pennsylvanian (95 feet thick; top 735 feet above sea level) —
"Gray sandstone, a little water" ---------- 135–157
"Coal blossom" ---------- 157–167
"Gray shale" ---------- 167–180
"Red shale" ---------- 180–189
"Gray shale" ---------- 189–230

Mississippian (undifferentiated, 233 feet thick; top 640 feet above sea level) —
"Gray limestone" ---------- 230–257
"Blue shale" ---------- 257–261
"Gray limestone" ---------- 261–289
"Black and gray shale" ---------- 289–298
"Gray limestone" ---------- 298–344
"Blue shale" ---------- 344–347
"White limestone" ---------- 347–437
"Blue shale" ---------- 437–448
"White limestone" ---------- 448–463

Kinderhook shale (94 feet thick; top 407 feet above sea level) —
"Blue shale" ---------- 463–557

Devonian (168 feet thick; top 313 feet above sea level) —
"White limestone" ---------- 557–575
"Blue shale" ---------- 575–595
"White limestone" ---------- 595–603
"Gray and blue shale" ---------- 603–625
"Gray limestone" ---------- 625–630
"Gray shale" ---------- 630–715
"Gray limestone" ---------- 715–720
"Gray shale" ---------- 720–725

Silurian (371 feet thick; top 145 feet above sea level) —
"White limestone" ---------- 725–1077
"Gray shale" ---------- 1077–1081
"Gray limestone" ---------- 1081–1096

Ordovician:

Maquoketa shale (259 feet thick; top 226 feet below sea level) —
"Mixed shale, blue and gray" ---------- 1096–1355

Galena-Plateville (235 feet thick; top 485 feet below sea level) —
"Gray limestone" ---------- 1355–1541
"Blue shale" (Decorah?) ---------- 1541–1549
"Gray limestone" ---------- 1549–1590

Saint Peter sandstone (33 feet thick; top 720 feet below sea level) —
"Saint Peter sandstone, hard and fine" ---------- 1590–1623

Prairie du Chien: Shakopee (167 feet thick; top 753 feet below sea level) —
"Gray limestone, hard" ---------- 1623–1755
Dolomite, light gray; much blue-green hard fissile shale, probably from Glenwood horizon ---------- 1660–1670
Dolomite, as above; 2 samples ---------- 1670–1690
No sample ---------- 1690–1700
Dolomite, light gray; siliceous oölite ---------- 1700–1710
Dolomite, light gray, considerable amount of shale as above; rather large quantity of well-rounded quartz sand ---------- 1710–1720
Dolomite, light yellow-gray and light gray; 4 samples; quartz sand noted at 1740 ---------- 1720–1760
"Crevices, no samples" ---------- 1755–1790
Dolomite, very light gray; siliceous oölite ---------- 1780–1790

Prairie du Chien: New Richmond sandstone (60 feet thick; top 920 feet below sea level) —
"Soft sandstone, light, very fine, Richmond" ---------- 1790–1875
Sandstone, light gray in mass, fine, irregular grains; some dolomite in equally fine chips ---------- 1790–1800

Sandstone, as above; a few grains of oölite noted ---- 1800–1810
Sandstone, light yellow-gray, some larger grains 0.5 to 0.8 mm. diameter, some well-rounded ---- 1810–1820
Sandstone, light gray, very fine irregular grains; 2 samples ---- 1830–1850
Prairie du Chien: Oneota dolomite (236 feet thick; top 980 feet below sea level) —
Dolomite, in fine meal; much sandstone as above ---- 1850–1860
Dolomite, very light gray, in fine meal; some fine sand; 2 samples ---- 1860–1880
Dolomite, as above, clean ---- 1880–1890
Dolomite, light yellow-gray ---- 1890–1900
Dolomite, light gray to buff, some cherty; 11 samples ---- 1900–2080
"White limestone, sandy" ---- 1875–1935
"Crevices; no sample" ---- 1935–1950
"Sandy limestone, brown" ---- 1950–1970
"Crevices, no sample" ---- 1970–1990
"Brown limestone" ---- 1990–1995
"Crevices in brown limestone; no sample" ---- 1995–2060
"Brown limestone" ---- 2060–2086
Cambrian:
Trempealeau: Jordan sandstone (53 feet thick; top 1216 feet below sea level) —
Sandstone, rusted light buff, larger grains rounded, frosted, smaller grains largely irregular and broken, maximum grains 0.7 to 0.8 mm. diameter; 3 samples ---- 2086–2108
Sandstone, as above; some dolomite, whitish; 2 samples ---- 2110–2120
Sandstone, dolomitic cement ---- 2127
Sandstone, as above, rusted buff, some secondary enlargements ---- 2130
Trempealeau: Saint Lawrence (top 1269 feet below sea level) —
Dolomite, light gray, rusted buff; much quartz sand in cuttings ---- 2139
"Gray limestone" ---- 2139

Notes. — This section is so normal that it requires little comment. One feature, however, deserves special mention here: In this case, the cavities in the Prairie du Chien, though often found in wells that penetrate that formation, are especially pronounced. According to the log, cavities were found at several levels. In one, the lowest, as the driller writes, the drill dropped about 14 feet, bending the jars.

The significance of solution channels in the dolomites of this terrane has been noted several times in earlier reports in connection with the circulation of underground water. However, so far as the writer is aware, they have never been correlated with the unconformity which parts the Prairie du Chien from the Saint Peter. Granting that the Prairie du Chien was long exposed as the country rock during the interval preceding the transgression of the Saint Peter sea, the development of underground drainage channels within the terrane follows as a matter of course. On the other hand, if the channels in the Oneota and Shakopee dolomites were wholly the work of the present circulation of ground water, it would seem as if crevices should be discovered by the drill as frequently in the superior limestone and dolomite terranes as in the Prairie du Chien.

Comparing the New Sharon section with that of Grinnell (City

well No. 2), it is seen that all formations, excepting the Maquoketa, from the Kinderhook to the Glenwood inclusive, have thinned notably south-southwestward in the distance of 19 miles — the Kinderhook from 167 to 94 feet, the Devonian from 216 to 168 feet, the Silurian from 414 to 371 feet, and the Galena-Platteville from 291 to 231 feet. The Maquoketa, however, with its erosion surface, is 48 feet thicker at New Sharon than at Grinnell. The thickness of the Saint Peter and of the terranes below is practically the same at both localities.

Newton, Jasper County

A deep well was completed in 1930 at Newton by the Thorpe Bros. Well Co. of Des Moines for E. H. Maytag. The depth is 2,567 feet; the diameters from 16 to 6 inches. The following permanent piping was placed: 12-inch from surface to 183 feet, 10-inch from surface to 702 feet, 8-inch from 1,048 to 1,258 feet, 6-inch from 504 to 1,750 feet.

Driller's Log	Depth in Feet
Pleistocene and Recent (85 feet thick; top 910 feet above sea level) —	
Blue clay	0–7
Yellow clay and boulders	7–35
Sand	35–41
Blue clay	41–75
Yellow clay and boulders	75–80
Blue clay	80–85
Pennsylvanian, Des Moines (96 feet thick; top 825 feet above sea level) —	
Limestone	85–93
Yellow clay	93–98
Black hard pan	98–102
Black shale	102–120
Limestone	120–136
Black shale	136–144
Limestone	144–161
Sandstone (water)	161–181
Mississippian, undifferentiated (261 feet thick; top 729 feet above sea level) —	
Red and blue shale	181–183
Limestone, hard	183–204
Green shale	204–208
Limestone	208–224
Green shale	224–230
Limestone	230–265
Green shale	265–272
Limestone	272–442
Mississippian, Kinderhook shale (93 feet thick; top 468 feet above sea level) —	
Shale	442–535
Devonian (125 feet thick; top 375 feet above sea level) —	
Limestone	535–585
Shale	585–591
Limestone	591–595
Shale	595–603
Limestone	603–611
Shale	611–660
Devonian (?) and Silurian (512 feet thick; top 250 feet above sea level) —	
Limestone	660–1172

Ordovician:
- Maquoketa shale (93 feet thick; top 262 feet below sea level) —
  - Red shale ---- 1172–1188
  - Limestone ---- 1188–1192
  - Red shale ---- 1192–1196
  - Limestone ---- 1196–1198
  - Red shale ---- 1198–1255
  - Shaly limestone ---- 1255–1265
- Galena-Platteville (435 feet thick; top 355 feet below sea level) —
  - Limestone ---- 1265–1362
  - No samples — washed away ---- 1362–1378
  - Limestone ---- 1378–1570
  - No samples — washed away ---- 1570–1610
  - Limestone ---- 1610–1651
  - No samples — washed away ---- 1651–1656
  - Limestone ---- 1656–1659
  - Green shale (Decorah?) ---- 1659–1665
  - Limestone ---- 1665–1700
- Glenwood (8 feet thick; top 790 feet below sea level) —
  - Green shale ---- 1700–1706
  - Limestone ---- 1706–1708
- Saint Peter (31 feet thick, top 798 feet below sea level) —
  - Sandstone ---- 1708–1739
- Prairie du Chien (472 feet thick; top 829 feet below sea level): Shakopee —
  - No samples — washed away ---- 1739–1810
  - Very little sample ---- 1810–1890
  - Limestone, no grit ---- 1890–1905
  - No samples — washed away ---- 1905–1910
  - Limestone ---- 1910–1922
  - No samples — washed away ---- 1922–1930
  - Sandy limestone ---- 1930–1965
- Prairie du Chien: New Richmond —
  - Sandstone ---- 1965–1968
  - Sandy limestone ---- 1968–1985
  - Sandstone, hard ---- 1985–2000
  - Sandstone, soft ---- 2000–2015
- Prairie du Chien: Oneota —
  - Limestone, hard ---- 2015–2048
  - Very little samples — washed away ---- 2048–2135
  - Limestone ---- 2135–2211

Cambrian:
- Trempealeau: Jordan (41 feet thick; top 1301 feet below sea level) —
  - Sandy limestone ---- 2211–2225
  - Sandstone ---- 2225–2240
  - Sandy limestone ---- 2240–2252
- Trempealeau: Saint Lawrence (221 feet thick; top 1342 feet below sea level) —
  - Limestone ---- 2252–2473
- Franconia (penetrated 83 feet; top 1563 feet below sea level) —
  - Shaly limestone ---- 2473–2491
  - Limestone ---- 2491–2506
  - Shale ---- 2506–2521
  - Shaly limestone ---- 2521–2524
  - No samples — washed away ---- 2524–2551
  - Shale ---- 2551–2556

Notes. — It is regrettable that no cuttings of this well were taken by the drillers, since at several points the geological section must be left in doubt. For the most part, however, the careful and full log permits a fair degree of certainty.

The basal limestones of the undifferentiated Mississippian probably include the upper beds of the Kinderhook. The Kinderhook shale is surprisingly thin, about one half the thickness found at Grinnell and at Des Moines. The base of the Devonian necessarily is uncertain. On the testimony of nearby wells at least 400 feet of the 512 feet of "limestone" between 660 and 1,172 feet must be given to the Silurian. In all probability cuttings would show by gypsum and anhydrite content that much of this measure should be assigned to the Salina group. There is no evidence that the Hoing sands were encountered.

The amount of red shale in the Maquoketa is exceptional but is about the same as in the Maquoketa at Ogden. The formation is 93 feet thick at Newton and is much thicker toward the east (at Grinnell it measures more than 200 feet); it is thinner to the west and at Des Moines has a thickness of only 33 feet. Cuttings would probably show that the upper beds of the Galena-Platteville are dolomitic, while the basal limestones are of the common "Trenton" facies. The general relations of the section here, including the Glenwood and Saint Peter, are those prevailing in eastern Iowa.

The thickness of the St. Lawrence is rather excessive, and it is quite possible that the lower beds of the "limestone" so assigned may be a sandstone of minute quartzose particles, whose chips much resemble those of the limestones of the Cambrian, and, because they carry glauconite in many samples, are referred to the Franconia.

Palisades-Kepler State Park, Linn County

In 1930 Mr. Charles D. Nolan drilled a deep well near the edge of the north bluff overlooking Cedar River at this park. The depth of the well is 632 feet; its diameters are 8 and 6 inches. The well is cased with a 5-inch casing from 398 feet to the bottom of the well and is perforated for the lower 30 feet to admit water from the upper strata of the Galena limestone. An 8-inch casing extends from the surface to 83 feet. "The well was tested to 35 gallons per minute with no drawdown below 125 feet."

Driller's Log	Depth in Feet
Pleistocene (83 feet thick, top 814 * feet above sea level) —	
Yellow and blue clay (loess and glacial till)	0–83
Silurian: Niagaran (272 feet thick; top 731 feet above sea level) —	
White lime	83–105
Yellow lime, shelly and bouldery, broken	105–175

* Authority, M. L. Hutton, Engineer and Superintendent.

White lime	175–205
Yellow lime	205–295
White lime	295–355
Ordovician:	
Maquoketa shale (270 feet thick; top 459 feet above sea level) —	
Blue shale, with occasional streaks of hard lime	355–370
Pink shale	370–384
Light buff shale with occasional strata of lime	384–392
Dark, sandy lime rock, somewhat crystallized	392–398
Dark slaty rock	398–407
Dark shale	407–430
Hard flinty rock	430–435
Light blue shale	435–480
Shale, somewhat darker than above	480–505
Sandy slate	505–525
Dark shale	525–585
Bluish shale	585–605
Light shale	605–625
Galena-Platteville limestone (penetrated 7 feet; top 189 feet above sea level) —	
Water bearing lime rock, mostly sandy	625–632

Sac City, Sac County

In 1930 the Thorpe Bros. Well Co. of Des Moines completed a well for the Iowa Canning Co. at Sac City. The depth of the well is 2,047 feet. At 574 feet, after the Saint Peter sandstone was passed, a test showed a capacity of 100 gallons per minute. The static level then stood at 113 feet below the curb. At 1,872 feet after passing the Jordan sandstone, the well was again tested, and its capacity was then found to be 175 gallons per minute. The static level stood at 123 feet. On completion of the well, the final test showed a capacity of 335 gallons per minute, lowering the head from 128 feet to 280 feet below the curb, where it stood with little variation during the test. The temperature of the water is reported as 50 degrees F.

Record of Strata with Parts of Driller's Log.	Depth in Feet
Pleistocene (383 feet thick; top 1,274 feet above sea level) —	
"Yellow clay"	0–80
"Blue clay"	80–383
Cretaceous (47 feet thick; top 891 feet above sea level) —	
"Black shale"	383–388
Sandstone, gray, fine, irregular grains, dolomitic; limestone, gray, dolomitic, residue of microscopic quartz; chips of vein quartz	388–390
Limestone, light buff, fine-grained, earthy, moderately rapid effervescence in cold dilute HCl; sandstone, gray, minute grains, highly pyritic, dolomitic; chert, gray, fine, granular	390–400
Limestone, etc., as above; considerable amount of drift material	410
Sandstone, medium to coarse, grains irregular, in sand; considerable buff limestone of moderately rapid effervescence; chips of black shale	415
Sandstone, gray, fine- to medium-grained, argillaceous, dolomitic, including grains of cryptocrystalline silica; limestone, gray, argillaceous, slow effervescence; chalcedonic silica; quartz sand; drab shale	420
Mississippian (340 feet thick; top 844 feet above sea level) —	
Dolomite, dark brown, finely crystalline-granular; considerable blue chert; much quartz sand	430

Dolomite and chert as above	435
Limestone, yellow-gray, fine-grained, earthy, in flaky chips; 3 samples	440–460
Limestone, light brown, crystalline-granular, moderately rapid effervescence	470
Limestone, gray and whitish, fine-grained, rapid effervescence, some chalcedony; lump of blue-green shale, calcareous	480
"Shale"	484–488
"Limestone"	488–493
"Shale"	493–496
Limestone, blue-gray, calcilutite, and fine-grained, rapid effervescence, in flaky chips	500
Limestone, yellow-gray, fine-grained, rapid effervescence	510
Limestone, gray and whitish mottled, finely crystalline-granular, rapid effervescence, in flaky chips	520
Limestone, light gray, earthy, rapid effervescence, in flaky chips (harder and in fine chips at 540); 5 samples	530–570
Limestone, grayish buff, finely crystalline-granular, rapid effervescence	580
Limestone, light gray, earthy, rapid effervescence; 4 samples	590–620
Limestone, grayish buff, crystalline-granular, moderately rapid effervescence	630
Limestone, dolomitic, grayish buff, rather slow effervescence	640
Limestone, gray, earthy, rapid effervescence, in flaky chips; limestone, dolomitic, yellow-gray	650
Dolomite, light gray-buff, finely crystalline-granular; white calcite	660
Dolomite, gray, finely crystalline-granular; 2 samples	670–680
Chert, gray; dolomite, gray	690
Chert, blue and gray; some dolomite; 3 samples	700–720
Dolomite, dark gray, vesicular	730
Dolomite, gray	740
Shale, light blue-gray, plastic, calcareous, in concreted masses; 2 samples	750–760
"Shale"	740–765
Devonian, Silurian (280 feet thick; top 504 feet above sea level) —	
Dolomite, yellow-gray, in fine chips; 4 samples	770–800
Dolomite, blue-gray; considerable concreting blue shale	810
Limestone, dolomitic, light yellow-gray, earthy, laminated	820
Dolomite, blue-gray and yellow-gray, much shale, blue and olive-green, calcareous	830
Dolomite, gray and yellow-gray; 4 samples	840–870
"Gray shale"	862–865
"Blue limestone"	865–870
"Gray shale"	870–875
Dolomite, drab	880
Dolomite, drab and blue-gray in mass; 5 samples	890–930
Dolomite, brown in mass; 10 samples	940–1030
Dolomite, gray	1040
Ordovician:	
Maquoketa shale (70 feet thick; top 224 feet above sea level) —	
Shale, blue, in concreted masses with much dolomite in fine chips	1050
Shale, greenish, in splintery chips, feebly calcareous; shale, drab, calcareous; dolomite	1060
Dolomite, gray; shale	1070
Dolomite, brown and gray; shale, light blue-gray in concreting masses	1080
Dolomite, buff; some shale	1090
Limestone, dolomitic, blue-gray	1100
Shale, blue, in concreted masses	1110
"Shale"	1052–1100
Galena-Platteville (350 feet thick; top 154 feet above sea level) —	
Dolomite, brownish gray and gray, highly cherty at 1180, 1190; 8 samples	1120–1190
Dolomite, highly cherty, deeply rusted	1210–1220
Dolomite, gray, cherty	1230
Dolomite, buff with greenish tinge, crushed to fine crystalline sand	1240
Dolomite, gray	1250–1260
Dolomite, gray and buff, largely in meal; 13 samples	1270–1390

Dolomite, gray, crystalline-granular, in fine chips ---------- 1400
Limestone, light blue-gray, argillaceous, moderately rapid effervescence, pyritiferous at 1420 ----------1410–1420
Shale, light blue, calcareous ----------1430–1440
Shale, blue-gray, in splintery chips, calcareous ---------- 1450
Limestone, cream-yellow and brownish, in thin flakes, rapid effervescence 1460
Glenwood shale (50 feet thick; top 196 feet below sea level) —
Shale, blue-green, in hard concreted masses; 5 samples----------1470–1510
Saint Peter sandstone (55 feet thick; top 246 feet below sea level) —
Sandstone, fine, grains of clear quartz well-rounded; much dark gray shale in friable concreted masses ---------- 1520
Sandstone, clean, except for splintery flakes of blue-green shale, larger grains well-rounded, frosted, maximum about 0.5 mm. diameter; 4 samples ----------1530–1560
Shale, blue-green, some brownish interlaminations in the concreted masses ---------- 1570
Prairie du Chien (225 feet thick; top 301 feet below sea level) —
Dolomite, light yellow-gray; much shale and quartz sand ---------- 1575
No samples ----------1575–1600
Dolomite, light buff; shale and quartz sand; 3 samples ----------1600–1615
Dolomite, light buff; more or less quartz sand, but no imbedded grains observed; 8 samples ----------1620–1690
Sandstone, grains well-rounded; larger grains 1 mm. diameter; some light yellow dolomite ---------- 1700
Dolomite, light gray, gray and buff; considerable quartz sand at 1,710; 9 samples ----------1710–1790
Cambrian:
Trempealeau: Jordan sandstone (72 feet thick; top 526 feet below sea level) —
Sandstone, white, grains well-rounded, frosted, larger about 8 mm. diameter ---------- 1800
Sandstone, light yellow in mass, mostly fine and broken grains---------- 1810
Sandstone, stained with ferric oxide, somewhat finer than at 1800 feet--1820–1830
Sandstone, stained with rust, grains fine or broken; 4 samples----------1840–1870
Trempealeau: St. Lawrence (68 feet thick; top 598 feet below sea level) —
Dolomite, minutely arenaceous, pyritic, some larger included grains rounded; or sandstone, dolomitic; shale, green, hard; much coarser quartz sand ---------- 1872
Dolomite, buff in mass, highly arenaceous, grains minute, angular ------ 1880
Dolomite, gray-buff, in powder, argillaceous, minutely arenaceous------ 1890
Dolomite, brown in mass, some fine quartz sand ---------- 1900
Dolomite, light gray, some fine quartz sand ---------- 1910
Dolomite, light yellow-gray, in crystalline flour ---------- 1920
Franconia:
Dolomite, or dolomitic limestone (effervescence somewhat more rapid than Galena or Le Claire dolomites), gray, highly quartzose with minute angular particles of quartz; glauconitic ---------- 1940
Sandstone, darker gray, of minute angular particles of quartz, and cryptocrystalline silica; dolomitic, glauconitic ---------- 1950
Dolomite, as at 1940; 4 samples ----------1960–1990
Sandstone, grains minute, calcareous, glauconitic; flakes of hard gray-green shale ---------- 2000
Dolomite, as 1940 ---------- 2010
Shale, dark green-gray, somewhat calcareous, in moulded masses, slightly quartzose ---------- 2020
Sandstone, grains as at 1950, dolomitic; much shale as above in splintery chips ---------- 2030
Limestone, light yellow-gray, somewhat quartzose, moderately rapid effervescence; shale as above; some fine quartz sand ---------- 2040
As above; some sandstone of minute angular particles; some cryptocrystalline silica with imbedded grains of crystalline quartz-------- 2047

Notes. — At Sac City the top of the Saint Peter sandstone had been

estimated to lie a little less than 200 feet below sea level.[9] The formation was struck, however, at 246 feet below sea level, so that the contour of -200 of the map should be drawn north instead of south of the town. Thus the gradient between Sac City and Holstein to the west is somewhat steeper than had been inferred. The thickness assigned to the Glenwood, 50 feet, is not unusual in northwestern Iowa, while it is far greater than obtains in the eastern parts of the state. Only a thin bed of limestone separates the Glenwood from heavy shales which occupy the place of the Decorah and Platteville in large part. For a discussion of the thickness of the Glenwood and its relations, the reader is referred to Deep Wells of Iowa, Iowa Geological Survey, volume XXXIII, pages 33-36.

It is perhaps worth noting that the entire group of formations lying between the base of the Maquoketa and the top of the Saint Peter maintains this far to the west its usual thickness, here 350 feet. The entire group of Paleozoics above the summit of the Saint Peter to the base of the Pennsylvanian, 1,040 feet thick at Sac City, thins about 200 feet to Holstein, where it measures 847 feet. Farther west, at Sioux City, only 260 feet can be assigned to this entire aggregate.

The formations below the Saint Peter at Sac City carry their usual facies. The aggregate thickness of the beds from the base of the Saint Peter to the well-marked glauconitic horizon of the Franconia is 365 feet at Sac City, but at Holstein it has thinned to 240 feet. At Sioux City, however, the interval from the top of the Saint Peter to the glauconitic Franconia measures 410 feet, while the aggregate thickness of the formations from the top of the Saint Peter to the pre-Cambrian floor of crystallines is thicker at Sioux City (670 feet) than at Holstein (590 feet).

Driller's Log	Depth in Feet
Yellow clay	0–80
Blue clay	80–383
Black shale	383–388
Limestone	388–415
Mud and sand	415–435
Limestone	435–484
Shale	484–488
Limestone	488–493
Gray shale	493–496
Limestone	496–740
Shale	740–765
Limestone	765–862
Gray shale	862–865
Blue limestone	865–870

[9] Deep Wells of Iowa: Iowa Geol. Survey, Vol. XXXIII, Plate I.

Gray shale	870–875
Limestone	875–1052
Shale	1052–1100
Limestone	1100–1405
Sandy shale	1405–1520
Saint Peter sandstone	1520–1570
Limestone	1570–1605
Sand and lime	1605–1700
Sand	1700–1715
Limestone	1715–1740
Sand	1740–1780
Limestone	1780–1800
Jordan sandstone	1800–1870
Lime and shale	1870–1970
Shale	1970–2015
Limestone	2015–2047

Shellsburg, Benton County

On January 1, 1932, C. W. Varner of Dubuque completed a well 342 feet deep for the town of Shellsburg. This well was part of a system of water works under construction by the Howard R. Green Co. of Cedar Rapids. The diameters are 12 inches down to 41 feet, 10 inches from 41 to 92 feet, and 8 inches thence to the bottom of the well. The well is cased to 92 feet, and from 41 to 92 feet the casing is perforated to admit water. It was estimated that one third of the flow of the well came from these strata, while two thirds came from the limestones below the 92 foot level. Until the well reached a depth of 50 feet, the static level stood at 25 feet; while drilling progressed from 50 to 75 feet the static level rose to 15 feet below the curb. On completion of the well the static level was 12 feet below the curb, with a draw-down of 9 feet when the well was being pumped at 70 gallons per minute.

A Westco Turbine pump was installed with a capacity of 60 gallons per minute against a 50 pound head. The pump delivers water directly to a pneumatic pressure tank which is connected to the distribution system. The turbine is set 130 feet below the curb. The discharge line of the pump is arranged with the air release valve to allow the water to flow back down into the well, filling the line with air every time the pump stops and thus eliminating, it is hoped, the necessity for operating the air compressor.

The hardness of the water totals 13.9 grains per gallon.

The cost of the well complete, including pump, pump house, and engineering services was $3,500.

Record of Strata	Depth in Feet
Pleistocene (21 feet thick; top 776 feet above sea level) —	
Sand, yellow, coarse	0–16
Clay, yellow, sandy, calcareous	16–21

Devonian: Cedar Valley (24 feet thick; top 755 feet above sea level) —
- Limestone, blue and yellow-gray, rapid effervescence in cold dilute HCl, highly fossiliferous with fragments of brachiopods, as *Atrypa reticularis, Orthis iowensis, spirifers,* etc. ---------- 21–25
- Limestone, yellow-gray, fossiliferous, rapid effervescence; 3 samples-- 25–40
- Limestone, gray, rapid effervescence ---------- 40–45

Upper Davenport (15 feet thick) —
- Limestone, blue-gray, fossiliferous, rapid effervescence; 3 samples---- 45–60

Independence (45 feet thick; top 716 feet above sea level) —
- Shale, blue, plastic, unctuous, with calcilutite, light brown, conchoidal fracture, very rapid effervescence. Chips of this limestone, of Lower Davenport facies, constitute the mass of the sample---------- 60–65
- Shale, blue, some drab; some in hard, light blue chips, highly calcareous; pyrite in aggregates of microscopic cubes, drusy crusts, and in minute rods. Considerable calcilutite as above in fine cuttings; some irregular grains of quartz sand; disc of crinoid stem; all concreted in friable masses ---------- 65–70
- Shale, light blue-green as powder, chips of hard, light blue shale, and much light brown calcilutite; fossiliferous: various fragments, *Tentaculites,* disc of crinoid stem; pyrite ---------- 70–75
- Shale, and calcilutite as above; crinoid stem disc ---------- 75–80
- Shale, light blue-gray in mass, with chips of calcilutite as above which constitute most of sample ---------- 80–85
- Limestone, light yellow-gray and buff, fine granular-crystalline, in flaky chips, moderately rapid effervescence, distintegrating under weak acid into minute crystalline grains; 3 samples ---------- 85–100
- Sandstone, whitish, grains fine, well-rounded, frosted, with imbedded particles of chalcedonic silica and hard, dark greenish siliceous masses, calcareous cement, passing into arenaceous limestone; limestone, fine-grained, light brown-gray; some shale ---------- 100–105

Otis limestone (65 feet thick; top 671 feet above sea level) —
- Limestone, light blue-gray, argillaceous, earthy; some sandstone as above, and shale ---------- 105–110
- Limestone, soft, light blue-gray, argillaceous, finely granular, moderately slow effervescence, disintegrating under weak acid; limestone, brown and gray, rapid effervescence; shale and crinoid stem disc from cave ---------- 110–115
- Limestone, light blue-gray, in large chips, soft, rather slow effervescence, earthy and argillaceous, distintegrating under weak acid, minutely quartzose; cave: shale as above and valve of *Duovillina variabilis,* Calvin * ---------- 115–120
- Limestone, as above ---------- 120–125
- Limestone, light yellow and brownish gray, calcilutite, hard, conchoidal fracture, moderately rapid effervescence, argillaceous residue; 3 samples; at 135-140 as cave: *Duovillina variabilis,* Calvin, and *Duovillina arcuata,* Hall.*---------- 125–140
- Limestone, very fine-grained, color as above, rather slow effervescence, disintegrating into fine grains ---------- 140–145
- Limestone, as above, cave: some shale ---------- 145–150
- Limestone, light yellow-gray, calcilutite, rather rapid effervescence; cave: *Strophonella reversa,* Hall, juvenile form*; some shale------ 150–155
- Limestone, light yellow-gray, rapid effervescence, blue-gray, rapid effervescence, finely arenaceous, highly argillaceous; considerable white chert; shale concreting limestone chips into masses which are friable with difficulty; considerable fine quartz sand, larger grains well-rounded; pyrite; some chips of blue-green shale; 2 samples--- 155–165
- Shale, blue-gray, calcareous, white and blue-gray chert, pyrite in lumps-- 165–170

Silurian: Niagaran (177 feet penetrated; top 606 feet above sea level) —
- Limestone, magnesian, or dolomite, very light yellow-gray, soft, fine-grained, earthy, moderately slow effervescence; much white and gray chert; 2 samples ---------- 170–180
- Dolomites and cherts; 30 samples (For detailed description of this section see record of strata of Canning Co. well, Shellsburg, Iowa Geol. Survey, Vol. XXXIII, p. 321) ---------- 180–342

* Identified by Dr. M. A. Stainbrook, Texas Technological Institute, Lubbock, Texas.

Notes. — This well section is of signal importance since it offers conclusive proof of the place of the Independence shales in the geologic column of the Iowa Devonian, the first conclusive proof that has come to the attention of the writer. Up to 1932 all students of the Independence, indeed, had assumed that it immediately overlies the Otis limestone of the Wapsipinicon stage. The writer, for example, had summed up at length the arguments in favor of this theory and, identifying the Kenwood shale of the Linn County report with the fossiliferous Independence, had traced the formation from Scott County to Fayette County in numerous outcrops.[10] Yet neither the type locality at Independence nor the outcrops at Linn Junction and Brandon, the only fossiliferous exposures then known, showed base or cover of the formation and could not wholly exclude the possibility that they were outliers of the Lime Creek shales. The similarity of these two faunas, which then was greatly exaggerated, lent some color to the hypothesis.

The recent discovery by Stookey of a shale with a marked Independence fauna, at the extreme western edge of the Devonian area, in the vicinity of Amana and near an outcrop of the Kinderhook, seemed at first sight to strengthen the doubt as to the true place of the Independence. It was, therefore, with close interest that the writer had studied the sections of all deep wells which penetrated the Wapsipinicon. In a number of instances he had arranged with drillers for special sampling over the critical horizons.

Up to 1932, however, these efforts had proved fruitless. Shales, indeed, had been found at the supposed Independence horizon, but they did not offer the testimony of Independence fossils. When it was learned that a second deep well was to be put down at Shellsburg, the writer secured the coöperation of Mr. Howard Green of Cedar Rapids, engineer in charge, resulting in a very complete and ample sampling of the well. Mr. Green's efforts were rewarded by the preservation of several readily identified fossils that are characteristic of the Independence. Since this corroboration was obtained, Stainbrook has communicated to the writer the result of his studies of the Lime Creek and Independence fauna, which disproves the possibility of their identity.

In this well section the lower beds of the Cedar Valley, from 45 to 60 feet, are assigned to the Upper Davenport on account of their tex-

10 Norton, W. H., Wapsipinicon Breccias of Iowa, Iowa Geological Survey, Vol. XXVII, pp. 395-399.

ture and position. At 60 feet the drill entered a wholly different formation, a light brown calcilutite of Lower Davenport facies, mingled in the cuttings with the blue shale of the Independence. This shale, in places fossiliferous, with more or less calcilutite, continued to a depth of 85 feet.

Calcilutite layers in place within the shale have been found in only one locality, Eagle Point in Fayette, among all the numerous outcrops of the Independence in eastern Iowa. Calcilutite fragments referable to the Lower Davenport, however, are in many places intermingled with the Independence, as are fragments of the underlying Otis. Under the strains and stresses of brecciation the thin brittle thin-layered Lower Davenport limestone is readily fragmented, especially as the shales beneath afford a yielding foundation. In numerous localities, though not in this Shellsburg section, the tough massive Upper Davenport limestone is also involved in the brecciation. Its fragments, in some instances having thin plates of Lower Davenport calcilutite attached, are mingled with the Independence shales. Therefore it seems less probable that at Shellsburg the calcilutite fragments in the cuttings from 60 to 85 feet belong to laminae of limestone interstratified with the shale than that they are commingled fragments from the brecciated Lower Davenport beds. In part, of course, they may be due to cave from the limestone in place. As to the first sample, from 60 to 65 feet, a probable interpretation is that it represents a passage from limestone to shale, from which the slush bucket brought up cuttings of both beds.

Below this shale mingled with calcilutite lies 15 feet of impure limestone, of the Kenwood type, but which is found also in the Otis. The presence beneath of a sandstone with cryptocrystalline silica, often found in the Kenwood, favors placing both limestone and sandstone with the Independence and putting its base at 105 feet.

The drill then entered earthy limestones, assigned with no great certitude to the Otis. Unquestionably Otis, however, are the calcilutites which begin at 125 feet. It is also worth noting that here the Otis can not supply the calcilutites present in the Independence cuttings, because of brecciation. The Independence fossils on record from these beds are not native to them. The thin fragile shells are unbroken and, moreover, they inclose shale of the Independence type. Clearly they had fallen, with caving shale from the Independence levels.

The arenaceous limestone, shale, chert, and sandstone, 155 to 270

feet, may be compared with a similar basal conglomerate of the Otis in Bremer and Fayette Counties. They may also be compared with the sandy shale at Iowa City and with the cherty, sandy shale found in the deep wells at Oakdale immediately above the Niagaran. These are now referred by the author to the basal conglomerate of the Devonian.

The Niagaran dolomite is of the Hopkinton facies, the Le Claire being absent, as was to be expected. This well did not reach the level of the exceptional Niagaran basal sandstone found in the Canning Company's well at Shellsburg, which may be compared to the Colmar, or Hoing, sandstone of Illinois.

Sutherland, O'Brien County

C. Rasmussen and Sons of Sioux City report a well drilled by them in 1930 for the town of Sutherland. The depth is 450 feet, of which 410 feet is cased. The diameter at top is 10 inches. The main supply was found at from 410 to 460 feet, probably in the Dakota sandstone. The static level is 225 feet below the curb and the yield 90 gallons per minute.

Driller's Log	Depth in Feet
Yellow clay	0–32
Blue clay	32–175
Sand	175–185
Coarse sand and gravel mixed with clay	185–194
Fine sand	194–197
Sand and clay	197–200
Sand, blue clay and gravel	200–204
Blue clay	204–220
Brown clay	220–235
Brown clay mixed with sand	235–304
White clay	304–326
Fine yellow sand	326–395
Black sticky clay	395–401
Yellow sand, drilled like sandstone but won't stand up	401–410
Yellow sandstone	410–420
White sandstone	420–450

Vinton, Benton County, City Well No. 3

This well is located on the flood plain of the Cedar River at approximately the same elevation as that of the wells drilled in 1889 and 1892. The depth is 1,505 feet, and the diameters are from 12 to 10 inches. Water was found in the Saint Peter sandstone, 912 to 950 feet; in the Jordan sandstone, 1,377 to 1,388 feet; and in the Lodi and St. Lawrence dolomite, 1,450 to 1,485 feet with the main supply at 1,475 to 1,485 feet. On completion in July 1932 the yield was 300 gallons per minute, with a draw-down of 90 feet. Six months later the

yield had increased to 330 gallons per minute, with a draw-down of 70 feet. The top bowl of the turbine pump is set at 135 feet, and the suction tail piece extends to about 155 feet.

While the drill was in the drift, the static level stood at 25 feet below the surface; it rose to 20 feet in the Devonian (depth of well 202 feet), and to 15 feet in the Niagaran (depth 224 feet). In the limestones of the Maquoketa (depth 526 feet) it stood at 12 feet, and in the Platteville (depth 850 feet) at 10 feet. It continued to rise as the drilling progressed, standing at eight feet in the Saint Peter (depth 950 feet), and at 6 feet in the Prairie du Chien (depth 1,000 feet). At completion of the drilling at 1,505 feet it stood at 8 feet below the surface, but on the insertion of 660 feet of 12-inch cast-iron casing, footing in the Galena, the static level fell to 41 feet below the surface, showing that the higher heads had been due largely to Devonian, Niagaran, and Maquoketa waters.

Besides the 12-inch casing mentioned above, a 10-inch steel casing was set from 810 to 960 feet, footing in the Upper beds of the Prairie du Chien, and perforated to admit the Saint Peter water. The temperature of the water is reported to be 49 degrees F.

The well was drilled in 1932 by the Thorpe Bros. Well Co. of Des Moines, who supplied the set of samples of the cuttings examined, and the above data were furnished by the H. R. Green Co., engineers, of Cedar Rapids.

Record of Strata	Depth in Feet
Pleistocene and Recent (94 feet thick, top 775 feet above sea level) —	
Soil, blackish, sandy	0–5
Sand, some gravel, gray, coarse	5–20
Sand, dark buff, finer	20–26
Till, blue-gray, predominantly clayey; 6 samples	26–80
Till, dark drab	80–90
Till, gray	90–94
Devonian: Wapsipinicon formation: Otis limestone (126 feet thick; top 681 feet above sea level) —	
Limestone, earthy; and calcilutite, brown and gray, rapid effervescence in cold dilute HCl; some gray chert; in large chips	94–97
Limestone, light yellow-gray, compact, rapid effervescence	97–100
Limestone, light buff, crystalline-granular, soft, in large flaky chips	100–110
Limestone as above, some of moderately slow effervescence; limestone, brown, rapid effervescence	110–120
Limestone, very light gray, fine-grained, compact; some calcilutite with conchoidal cleavage; a considerable amount of blue and drab chert; some shale forming hard lumps with the cuttings	120–130
Limestone, very light gray, very fine-grained; and calcilutite; some white chert; 3 samples	130–160
Limestone, magnesian, or dolomite, light blue-gray, compact, rather slow effervescence, argillaceous residue, in large flaky chips; 2 samples	160–180
Limestone, light greenish gray, earthy, fine-grained, rapid effervescence, argillaceous, in large chips	180–190

Limestone, as above; some dark chert ---------- 190–200
Limestone, light yellow-gray, fine-grained, compact, earthy, rapid effervescence; much black chert; 2 samples ---------- 200–220
Silurian: Niagaran (126 feet thick; top 555 feet above sea level) —
Dolomite, light yellow-gray, compact, effervescence rather slow ---------- 220–230
Dolomite, blue-gray, vesicular ---------- 230–240
Dolomite, gray and blue-gray, much chert at 320, 10 samples ---------- 240–346
Ordovician:
Maquoketa shale (254 feet thick; top 429 feet above sea level) —
Shale, green, plastic ---------- 346–348
Shale, pink and bright buff ---------- 348–350
Shale, red and yellow ---------- 350–360
Shale, blue ---------- 360–370
Shale, greenish gray ---------- 370–380
Shale, blue, plastic; 11 samples ---------- 380–500
Limestone, drab, crystalline, highly argillaceous; limestone, light gray, crystalline, rapid effervescence; some gray chert; in fine sand and powder; 3 samples ---------- 500–530
Limestone, light yellow-gray and drab, soft, earthy, rapid effervescence, argillaceous residue, slightly quartzose with fine irregular grains, cherty ---------- 530–540
Dolomite, brownish and drab, soft, earthy, argillaceous, rather slow in effervescence; limestone, gray, rapid effervescence ---------- 540–550
Limestone, drab and gray, argillaceous, rapid effervescence ---------- 550–560
Shale, drab, with much limestone, drab, earthy, rapid effervescence ---------- 560–567
Shale, drab, in concreted masses; 4 samples ---------- 567–600
Galena-Platteville (300 feet thick; top 175 feet above sea level) —
Limestone, light yellow-gray, earthy, rapid effervescence, in flaky chips; 3 samples ---------- 600–630
Limestone, light yellow-gray and gray, rapid effervescence, most samples in flaky chips; 12 samples ---------- 630–750
Limestone, magnesian, or dolomite, yellow-gray, rather slow effervescence, cherty ---------- 750–760
Limestone, magnesian or dolomite, yellow-gray, rather slow effervescence; limestone, lighter gray, rapid effervescence, in larger chips ---------- 760–770
Limestone, magnesian or dolomite, as above; limestone, gray, crystalline, rather rapid effervescence ---------- 770–780
Limestone, light yellow-gray, compact, some dark gray, argillaceous, both rapid effervescence; buff chert ---------- 780–790
Limestone, light yellow-gray and blue-gray, rapid effervescence; 5 samples ---------- 790–834
Shale, blue and blue-green, calcareous, in hard concreted masses inclosing chips of shale and limestone ---------- 834–843
Limestone, light yellow-gray, gray and blue-gray, rapid effervescence; 6 samples ---------- 843–900
Glenwood shale (12 feet thick) —
Shale, blue-green, in hard concreted masses, calcareous; 2 samples ---------- 900–912
Saint Peter sandstone (38 feet thick; top 137 feet below sea level) —
Sandstone, light yellow-gray in mass from slight amount of powder coating grains, grains of clear quartz, well-rounded, frosted, up to 1 mm. diameter ---------- 912–920
Sandstone, white, grains as above; 3 samples ---------- 920–950
Prairie du Chien (420 feet thick; top 175 feet below sea level) —
Dolomite, light brown, cherty at 950, light buff at 990; 5 samples ---------- 950–1000
Dolomite, gray ---------- 1000–1010
Dolomite, gray; considerable quartz sand in cuttings; 2 samples ---------- 1010–1030
Dolomite, very light gray, gray and buff; 6 samples ---------- 1030–1090
Dolomite, gray; much sand in cuttings; 2 samples ---------- 1090–1110
Sandstone, fine to medium, larger grains well-rounded, in mass very light gray; 2 samples ---------- 1110–1130
Dolomite, light gray, blue-gray, and buff; 6 samples ---------- 1130–1186
Sandstone, fine to medium, grains well-rounded ---------- 1186–1191
Sandstone as above; dolomite, whitish, sporadically arenaceous; 2 samples ---------- 1191–1200

Dolomite, cherty at 1250, and 1280–1340, highly cherty 1210 and 1270; 16 samples ---------- 1200–1360
Dolomite, light buff, slightly arenaceous ---------- 1360–1370
Cambrian:
Trempealeau: Jordan sandstone (70 feet thick; top 595 feet below sea level) —
Sandstone, fine to medium, well-rounded frosted grains; dolomite, sporadically arenaceous ---------- 1370–1380
Sandstone, as above, dolomite ---------- 1380–1385
Sandstone, as above, whitish and light yellow-gray in mass; a little dolomite; 2 samples ---------- 1385–1395
Sandstone, fine to medium, white, larger grains well-rounded and frosted; 2 samples ---------- 1395–1405
Sandstone, as above, in loose grains; some chips of fine sandstone with dolomitic cement ---------- 1405–1410
Sandstone, fine to medium, grains as above; 3 samples ---------- 1410–1440
Trempealeau: Lodi and St. Lawrence (penetrated 65 feet; top 665 feet below sea level) —
Dolomite, in light gray powder, siliceous; or sandstone, dolomitic; quartz in minute irregular particles ---------- 1440–1450
Dolomite, blue-gray, in fine chips, minutely quartzose and pyritic ---------- 1450–1460
Sandstone, light gray, fine well-rounded grains, somewhat dolomitic, pulverized; 3 samples ---------- 1460–1477
Dolomite, light gray, minutely quartzose, in fine meal, trace of siliceous oölite; 2 samples ---------- 1477–1485
Franconia:
Sandstone, microscopically quartzose, dolomitic, glauconitic, in fine gray chips; 3 samples ---------- 1485–1505

Notes. — Of the two city wells already drilled in Vinton, well No. 1 was very imperfectly sampled, and the only geological information from well No. 2 was a log at variance at several points from the section of well No. 1. Fortunately, well No. 3 is sampled with exceptional fullness and evident accuracy, and it affords a very reliable geological section.

The Pleistocene part of the section discloses the fact that the wide ancient preglacial or pre-Kansan valley of the Cedar had been cut here to a depth of 94 feet below the present flood-plain level, in marked contrast with such narrow stretches of the present valley as that at Cedar Rapids, where the channel is rock-cut. Before the end of the Kansan this ancient valley had been deeply filled with the ground moraine of a continental ice sheet.

The *Spirifer pennatus* beds of the Cedar Valley stage outcrop in the town. All the Devonian section below this horizon is cut out by the ancient valley as far as the Otis limestone of the Wapsipinicon stage, of which there remains 126 feet. The total thickness to be allowed for the Devonian at Vinton thus reaches the exceptional figure of about 245 feet.

The Niagaran, which at Cedar Rapids was found to be 349 feet thick, has thinned at Vinton to 126 feet. Farther to the northwest, at

Waterloo, it thins to 107 feet, and at Waverly to 50 feet. The basal cherty layers are here unusually thin.

The Maquoketa shale, 254 feet thick, exhibits a thickness somewhat less than that at Cedar Rapids (276 feet), but more than that at Waterloo (215 feet) and at Waverly (150 feet). The intercalated limestones, not uncommon in the Maquoketa, here are in unusual strength. They suggest an alternative reference for any shales in deep well sections which have been interpreted as belonging to the upper beds of the Galena.

The Galena-Platteville at Vinton is notable for the almost complete absence of dolomitization. In none of the deep well sections of Iowa is this condition approximated except at Postville and Manchester. The significance of varying dolomitization in a body of sediments traversed by definite life zones was early pointed out by Norton [11] and much more fully discussed by Calvin.[12] The Saint Peter and the Prairie du Chien run true to form. The Jordan is well marked and shows its customary well-rounded grains. The Lodi and St. Lawrence dolomite is either arenaceous or minutely quartzose. The dolomitic and glauconitic sandstone at 1,485 feet, whose quartz grains are microscopic, has been assigned to the Franconia.

Waverly, Bremer County, City Well No. 2

In July, 1930, Thorpe Bros. Well Co. of Des Moines completed a second deep well for the town of Waverly. The first well, drilled in 1899, with a bottom diameter of 8 inches, could not deliver enough water to meet the town's increasing peak demand of the summer at the canning season. This well had been sunk 480 feet below the base of the Jordan sandstone before drilling was stopped at the advice of this office. The second well evidently should not be drilled to so great a depth, but its diameter should be larger. A capacity of 700 gallons per minute was desired.

The 1930 well is 1,263 feet deep, drilled 60 feet below the Jordan aquifer into the St. Lawrence dolomite for sedimentation. The bottom diameter is 12 inches. Water was found at 260 feet at top of the Galena-Platteville and at 580 feet in the same formation, from 677 to 715 feet in the Saint Peter sandstone, and the main supply in the Jordan sandstone from 1,105 to 1,170 feet.

11 Artesian Wells of Iowa: Iowa Geol. Survey, Vol. VI, pp. 145-147.
12 Geology of Dubuque County: Iowa Geol. Survey, Vol. X, pp. 402-411.

The static level of the well is 42.5 feet below the surface. The advance of thirty years in casing deep wells is seen by comparing the scant 100 feet of casing in the well of 1899, reaching only to within ten feet of the base of the Niagaran limestone, with that of the well of 1930. Here wrought-iron casing 28 inches in diameter was inserted from the surface to 110 feet, resting on basal layers of the Niagaran. Inside this is placed a cast-iron casing 16 inches in diameter extending through the Maquoketa shales to 271.5 feet, where it is bedded in the solid rock of the Galena. The space between these casings is filled with concrete. Thus effectively is prevented the admission of any water from the soluble and creviced limestones overlying the dry impervious Maquoketa shales. From the bottom of the 16-inch casing a 12-inch cast-iron casing extends to 771.5 feet, where it is based in the Shakopee dolomite. It is perforated from 502 to 550 feet to admit water from the Galena-Platteville, and from 694 to 742 feet through the Saint Peter water bed. A packer is set at 692 feet to shut out cave from the Glenwood shale. Pumping tests made on penetrating the Saint Peter showed a yield of nearly 150 gallons per minute. On completion the well yielded 624 gallons per minute with a 200 foot draw-down, and 695 gallons per minute with a draw-down of 233 feet.

The above data were largely supplied by Mr. E. E. Schenk, city engineer.

Driller's Log	Depth in Feet
Pleistocene and Recent (50 feet thick) —	
Soil	0–3
Yellow clay	3–9
Yellow sand	9–50
Devonian and Silurian (67 feet thick) —	
Loose rock and mud	50–55
Soft rock and yellow clay	55–110
Lime rock, grayish blue	110–117
Ordovician:	
Maquoketa shale (143 feet thick) —	
Blue shale	117–131
Shale and streaks of rock	131–145
Shale (greenish)	145–160
Shale (grayish blue)	160–248
Lime rock and streaks of shale	248–260
Galena-Platteville (400 feet thick) —	
Brown lime	260–375
Gray lime	375–585
Lime and shale	585–660
Glenwood shale (17 feet thick) —	
Shale and thin streaks of rock	660–677
Saint Peter sandstone (41 feet thick) —	
Fine sand	677–718
Prairie du Chien (387 feet thick) —	
Lime rock (Shakopee)	718–895
Soft sand (New Richmond)	895–907

Lime rock (Oneota)	907–1105
Cambrian:	
Trempealeau: Jordan sandstone (95 feet thick) —	
Soft sand and thin hard streaks	1105–1170
Sandy lime	1170–1200
Trempealeau: St. Lawrence (penetrated 63 feet) —	
Limestone	1200–1263

West Point, Lee County

A well 1,154 feet deep was drilled in 1931 for the town of West Point by Thorpe Bros. Well Co. The diameters are from 8 to 6 inches. The only water bed of consequence is the Saint Peter sandstone, yielding on completion of the well about 80 gallons per minute with a draw-down of 50 feet. The lower 54 feet of the well is uncased. Two hundred and forty-eight feet of 8-inch casing is coupled to 842 feet of 6-inch casing. The static level is about 190 feet below the curb.

Driller's Log	Depth in Feet
Pleistocene and Recent (159 feet thick; top 763 feet above sea level) —	
Soil	0–28
Blue clay	28–159
Mississippian, undifferentiated (292 feet thick; top 604 feet above sea level) —	
Limestone and shale	159–240
Brown limestone	240–289
White limestone	289–379
Shale	379–388
Limestone	388–451
Mississippian, Kinderhook shale (274 feet thick; top 312 feet above sea level) —	
Shale	451–725
Devonian-Silurian(?) (134 feet thick; top 38 feet above sea level) —	
Gray limestone	725–727
Brown limestone	727–805
Brown and gray limestone	805–856
Dolomite	856–857
Brown limestone	857–859
Ordovician:	
Maquoketa shale (9 feet thick; top 96 feet below sea level) —	
Gray shale	859–868
Galena-Platteville (217 feet thick; top 105 feet below sea level) —	
Brown limestone	868–1085
Saint Peter sandstone (69 feet thick; top 322 feet below sea level) —	
Sandstone	1085–1153
Shale	1153–1154

Notes. — The geologic section of this well is made out with the help of the Donnellson section, which it closely parallels. The upper beds of the Mississippian may be referred to the Meramec and Keokuk, and the "white limestone" of the log describes a common facies of the Burlington. As at Fort Madison, Burlington, and Mount Clara, the Kinderhook shales are present in great force. They are more than 50 feet thicker than at Keokuk, but some 50 feet thinner than at Donnellson.

In this area the Silurian has apparently feathered out, as at Donnellson and Keokuk. Its presence at West Point is very doubtful, where all the limestones between the Kinderhook and the Maquoketa shales are of Devonian types. The Maquoketa is slightly thicker than at Donnellson. Apparently from the log the same conditions obtain in the Galena-Platteville as at Donnellson, where the entire terrane is dolomitic. Neither limestones of Trenton facies, nor shales representing the Decorah are present, and with them the Glenwood shale also has disappeared. At Keokuk, also, the Platteville and Glenwood are out of the lithologic picture except for some chips of a bituminous shale in one sample of cuttings from the horizon of the Platteville.

The elevation of the top of the Saint Peter, 22 feet higher than at Donnellson, was pretty accurately forecast on our last contour map of this horizon.[13]

Bragieton Farm Well, Calhoun County

This well was drilled for Charles W. Bragieton by J. J. Becker of Fort Dodge in 1931. It is located in the SE¼ section 5, Lincoln Township, Calhoun County, Iowa. The well is 617 feet deep and its diameters range from five to three inches. It is cased to 600 feet with 5-inch to 3-inch casing. A little water was found at 100 feet but no other supply at a greater depth. This well was never finished.

This boring is of special interest in that it practically duplicates, so far as it goes, the highly abnormal geologic section of the deep wells at Manson. It will be recalled that at Manson beneath 200 feet of Pleistocene deposits lay 790 feet of shale with some sandstone, the cuttings mingled with a considerable amount of pebbles and sand largely if not wholly from the drift above. These shales rested on soft arkosic sandstones yielding generously water of a quality altogether exceptional in Iowa deep wells — soft, alkaline, "the solids being mostly alkaline chlorides and sulphates." [14] The explanation of the writer was that a deep erosion channel or basin had been filled in part by continental deposits brought in from igneous rocks to the north; and later it was filled by estuarine clays, Pennsylvanian or Cretaceous in age.[15]

The water bed of arkosic sands in this ancient valley doubtless lies too deep for profitable exploitation by farm wells, but possibly future

13 Deep Wells of Iowa: Iowa Geol. Survey, Vol. XXXIII, Plate 1.
14 Hendrixson, W. S., Underground Water Resources of Iowa: Iowa Geol. Survey, Vol. XXI, p. 174.
15 Deep Wells of Iowa: Iowa Geol. Survey, Vol. XXXIII, pp. 246-254.

wells of one or more towns in Calhoun and Pocahontas Counties may strike it and extend our knowledge of the abnormal geological conditions of this restricted area.

Record of Strata By James H. Lees	Depth in Feet
Pleistocene and Recent:	
Till, glacial clay, calcareous, blue-gray, many limestone pebbles	60–90
Sand, gray, clean, irregular in size, numerous limestone pebbles	100
Sand, similar to above	110–130
Till, glacial, similar to that at 60 to 90, limestone pebbles respond only slowly to acid	140–150
Till, similar to above	160
Till, mostly yellow, some blue-gray, yellow is nearly leached of lime, blue is somewhat limy, a few small gravel bits of limestone, others not limy	170
Sand, glacial, yellow from clay, grains irregular, responds briskly to acid	180
Till, glacial, yellow, very limy	190
Till, buff, limy	200
Till, yellow and gray, limy	210
Till, blue-gray, limy, pebbly	220
Till, like that above, shows sand grains	230
Mississippian:	
Shale, blue-gray, finely sandy, limy, hardly distinguishable from glacial till	240
Same	250
Same	260
Same	270
Same, limy, sandy	280
Same	290
Same	310
Same	325
Shale, gray, very finely gritty, very slightly limy, in small chips; sand, irregular, rounded to angular, some masses like those from 325 and above	350
Shale, gray, limy, similar to that above 325	360
Same	390
Same	400
Same	410
Same	420
Shale, limy, and fine gravel and sand	430
Shale, limy and finely sandy with clean quartz	440
Same	450
Shale, dark gray, fine-textured, limy, mingled with sand and gravel	460
Sand, including grains of flint, quartz, calcite, limestone, dark rock particles, not much shale	470
Same; some fragments concreted with calcite cement	480
Same, some chips of very smooth, nonlimy shale	490
Shale, dark gray, coarsely gritty with sand like that above, very limy; some fragments of white crystalline quartz	510
Sand, similar to that from 470 to 490	530
Same	540
Shale, dark gray, smooth, nonlimy; and sand similar to that above; in equal amounts	550
Shale, dark gray, sandy and limy, with some fragments of sandstone which are only slightly limy	560
Shale, fine-textured, limy, dark gray	570
Same	580
Shale, similar to above; and sand, similar to that above, some fragments of chert	590
Shale, probably like that above; fragments of clay mingled with sand and concreted with lime	600
Same	610

Nixon Farm Well near Stockport

The following is the driller's log of a deep well drilled on the farm of A. Nixon, three and one-half miles southeast of Stockport, Van Buren County, by S. Shearard, Colchester, Illinois. It is noteworthy as confirming the great thickness of the Kinderhook shale in this area.

Driller's Log	Depth in Feet
Pleistocene (40 feet thick) —	
Surface formation	0–40
Mississippian, undifferentiated (280 feet thick) —	
Limestone	40–85
Slate, muddy	85–110
Lime	110–270
Slate	270–272
Limestone	272–320
Mississippian, Kinderhook shale (322 feet thick) —	
Slate and shale	320–380
Limestone, shell	380–385
Blue shale	385–430
Brown shale	430–470
Light blue shale	470–635
Salt water sand	635–642

Titus-Merrill Farm Well, Muscatine County

Three and one-half miles southwest of Muscatine

Driller, W. S. Cole of Plymouth, Ill.

Driller's Log	Depth in Feet
Pleistocene (140 feet thick) —	
Surface gravel	0–90
Gravel rock	90–140
Devonian and Silurian (294 feet thick) —	
Gray lime rock	140–170
White lime rock	170–207
Brown lime rock	207–247
Gray lime rock	247–270
Blue lime, water	270–325
White lime	325–340
Gray shale	340–347
Blue lime, water	347–377
White and gray lime	377–389
Brown lime	389–415
Light brown lime	415–434
Ordovician:	
Maquoketa shale (217 feet thick) —	
Gray shale	434–466
Lime and shale	466–486
Gray shale	486–585
Brown shale, very hard	585–629
Black shale	629–651
Galena-Platteville (penetrated 31 feet) —	
Gray hard lime	651–652
Brown lime	652–656
Light brown lime, water	656–682

Farm Wells, Woodbury County

Mr. C. C. Everhart of Moville supplies the following data of sev-

eral wells near Moville drilled by C. Blackford. J. H. Wright farm well, E½ sec. 17, T. 89 N., R. 44 W. The main supply was found at 145 feet; the static level is 60 feet below curb.

Driller's Log	Depth in Feet
Loess	0–80
Clay and hardpan	80–125
Coarse sand	125–145

Charles Logan farm well, SW¼ NW¼ sec. 5, T. 88 N., R. 43 W. The main supply of water was found at 312 feet.

Driller's Log	Depth in Feet
Loam, loess, fine sand	0–53
Boulders, etc	53–65
Boulders, black mud	65–105
Hardpan	105–180
Gravel	180–298
Sandrock	312–315 (sic)

Frank Wright farm well, S½ sec. 25, T. 89 N., R. 44 W. The main supply was found at 345 feet, and the well is cased to 344 feet.

Driller's Log	Depth in Feet
Loess	0–60
Sand loess	60–145
Glacial soil, large boulder at 185 feet, mineral water at 217 feet	145–217
Sand rock, gravel, etc.	217–250
Black shale or very hard hardpan	250–336
Large sand pocket, sand black and fine, small section of petrified wood, at 338 feet	336–348